

BKK CORPORATION



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PLAN FOR
DETAILED INVESTIGATION OF THE
BKK DISPOSAL FACILITY
AND THE
AFFECTED SURROUNDING AREA
WEST COVINA, CALIFORNIA

^{4/E}
5-21-84

Prepared by

BKK Corporation
2550 - 237th Street
Torrance, California 90501

May 21, 1984



May 21, 1984

California Regional Water Quality Control Board -
Los Angeles Region
107 South Broadway, Suite 4027
Los Angeles, California 90012

Attn: Mr. Robert P. Ghirelli
Executive Officer

Honorable Members:

In compliance with your letter of April 20, 1984, as amended, BKK Corporation is submitting herewith several reports which constitute a plan and time schedule for completing the detailed investigation of the BKK Disposal Facility and the affected surrounding areas and recommending certain early mitigation measures.

This response has been generated through our efforts and those of several consultants with primary responsibilities as follows:

| | |
|---------------------------------------------------------------------------|-------------------------------|
| Site Characterization Plan - | LeRoy Crandall and Associates |
| Liner and Barrier Study Plan - | " " " " |
| Subsurface Mitigation Plan - | " " " " |
| Development Plan for Landfill Gas Control and Recovery - | Mandeville & Associates |
| Plan for Developing a Surface Hydrology Model - | Williamson & Schmid |
| Management Plan for the Disposal of Leachate and Collected Waters - | BCL Associates, Inc. |
| Sampling Protocols - | BCL Associates, Inc. |
| Analytical and Quality Control Protocols - | BCL Associates, Inc. |
| Safety Plan for Investigations - | BCL Associates, Inc. |

California Regional Water Quality Control Board

May 21, 1984

Page Two

For site characterization, the Crandall organization outlines studies to date and the remaining existing and new tasks yet required to complete the hydrogeologic studies. Included is a time line for the completion of studies and analysis, based on a planned, orderly sequence for the remaining work.

The revised liner and barrier study by Crandall details the test procedure for Barriers 1 and 2 to determine their adequacy.

Crandall and Associates' preliminary draft of subsurface mitigation measures discusses the two areas with potential for movement of liquids outside the Class I area. Alternative measures are discussed. The pumping trough alternative is preferred. Crandall's position is that certain of these mitigation methods could be implemented now since the characterization studies are sufficiently complete to identify remedial measures that can be expected to prevent future liquid migration should it occur.

Mandeville's contribution puts gas migration and control into perspective. His maps and dialogue outline an effective plan to control landfill gas movement. Indications from water samples taken at several locations provide strong evidence that such contaminants as have been found in the water samples are due to gas transport.


The leachate management plan presented by BCLA assesses the need for permanent and interim liquid management. In order to facilitate current exploratory studies, the recycling of leachate and other collected waters which may not be readily treated for on-site uses, including disposal in new, dry municipal refuse is outlined.

The sampling, analytical and quality control protocols, as itemized by BCLA outline procedures to be followed to establish the highest level of reliability for testing.

The Safety Plan, developed by BCLA, ensures the health and welfare for the workplace and the surrounding community.

With these submittals, BKK feels that it has adequately responded to your concerns and requirements. We are pleased to submit these work plans for your approval, and we stand ready to discuss or clarify any issues you select.

Sincerely,


Robert L. Litzenberg, P.E.
Chief Engineer

Enclosures

TABLE OF CONTENTS

Section

| | |
|-----|--------------------------------------------------------------------------|
| ✓ 1 | Site Characterization Plan |
| 2 | Liner and Barrier Study Plan |
| 3 | Subsurface Migration Plan |
| 4 | Development Plan for Landfill Gas Control and Recovery |
| 5 | Management Plan for Disposal of Leachate and Other Collected Site Waters |
| 6 | Sampling Protocols |
| 7 | Analytical and Quality Control Protocols |
| 8 | Safety Plan for Investigations |
| 9 | Statement of Provisions for Gaining Access |
| 10 | Certification of Consistency |
| 11 | Contributing Consultants |

— off-site chapter needed EPA items.
— air quality work plan.

SITE CHARACTERIZATION PLAN

1



May 18, 1984

BKK Corporation
2550 237th Street
Torrance, California 90510

(Our Job No. E-83124-E)

Attention: Mr. Ken Kazarian
Vice President

Gentlemen:

Site Characterization Plan
BKK Landfill
West Covina, California

Transmitted herewith is our Site Characterization Plan as required by the Regional Water Quality Control Board letter dated April 20, 1984. The plan has been discussed with Messrs. Gastelum and Litzenberg.

Should you have any questions, please do not hesitate to call.

Yours very truly,

LeROY CRANDALL AND ASSOCIATES

by

Glenn A. Brown, C.E.G. 3
Director of Geological Services

GAB/D59
(25 copies submitted)

SITE CHARACTERIZATION PLAN

BKK WEST COVINA LANDFILL

INTRODUCTION

It is the purpose of this site characterization plan to meet the site characterization plan requirements of the Regional Water Quality Control Board's letter dated April 20, 1984, as amended, and EPA Administrative Order of Consent agreed upon by BKK Corporation and EPA on April 24, 1984. The letter and the Consent Order require BKK Corporation to submit a plan to completely determine the hydrogeology of the BKK disposal site and the affected surrounding area in adequate detail to characterize any movement of contamination originating from the BKK facility.

In the development of this plan, we have fully considered the magnitude of the hydrogeologic work accomplished to date. This work has been accomplished in response to DOHS Field Memorandum, rather than previously submitted plans (see Submittals to DOHS, dated November 2, 1983 and March 23, 1984). This prior work has included detailed geologic mapping of the 583-acre parcel at a scale of 1" = 200', and the east-central portion of the site at a scale of 1" = 50'. In addition to the surface investigation, 5 core holes, 19 monitoring-extraction wells, and 20 bucket auger borings have been drilled and logged. Ninety-five test pits have been excavated and logged.



The site characterization study presently underway under the direction of DOHS, requires the drilling of a minimum of five more core holes ^{to depth of interconnected flow zones into underlying} (2000 lineal feet). This is in addition to the six core holes ^{aquifer} which have been completed or are partially completed at this time.

Before full characterization of the site is accomplished, additional time will be needed to recheck some of the geologic mapping, and to prepare geologic sections which will depict the general framework of the site in the third dimension. It has already been established that the geology of the site has been extremely complicated by minor faulting and folding. The faulting and folding will ^{add to it. only those that are tight} ~~actually retard~~ liquid ^{false} movement, and does not rule out the use of proven mitigation methods. ^{see Bibliography} The additional site characterization will provide useful information, but further work much beyond that which is described herein, in our opinion, is beyond the point of diminishing return. Sufficient characterization has been completed, however, to design and recommend an effective mitigation program at this time. ^{limited}

The subsurface data coupled with the geologic mapping efforts ^{to} ~~to~~ date have indicated that in terms of hydraulic integrity, there are ^{known} ~~two~~ ⁴ ~~5~~ primary areas around the perimeter of the landfill where a potential for liquid contaminant escape from the waste management ^{unit} ~~areas may exist~~. These areas have been termed "Area A", located along the southeastern property line in the vicinity of Miranda Street, and "Area B", located in the lower reaches of the stream channel at a topographic constriction between Azusa Avenue and the BKK office complex. Potential movement



from Area A and Area B can be controlled by means described in detail in the Subsurface Mitigation Plan.

ADDITIONAL GEOLOGIC FIELD WORK

Recent subsurface exploration, including the drilling of 14 bucket auger borings, between monitoring well sets MW-18A-B and MW-19A-B, indicates the presence of a very tightly folded sequence of sedimentary rock or the presence of a fault zone accompanied by severely contorted bedding. The understanding of the hydraulic significance of this feature requires a considerable amount of additional geologic field work.

It is our opinion that if a fault is found to be present, it may partially or entirely sever the hydraulic continuity of the sandstone bed in Area B, thus lessening concerns about hydrologic integrity. The suspected fault feature appears to be a splay off the San Jose Fault, which is a known barrier to ground water movement in the vicinity of the City of Pomona. (Although such a faulting pattern would provide an additional natural barrier to liquid movement,) the mitigation measures outlined in our Subsurface Mitigation Plan are still recommended for complete assurance of containment.

The additional site characterization activity which is beyond our original anticipation, is therefore required. This new work can be divided into the following tasks: 1) geologic mapping, 2) excavation of test pits, 3) core drilling, and 4) the construction of monitoring-extraction wells for mitigation (liquid extraction). The location of the area to be mapped is shown on Figure 1, Location Map.



Test pits will be excavated by backhoe equipment within the area to be mapped. The pits will be located by the field geologists on an as-required basis. Therefore, the number of test pits cannot be stated at this time.

The geologic data presently available suggests that core holes should be drilled in at least two pairs at the locations shown on Figure 1. It would be the purpose of the core hole pairs to straddle the inferred feature and to gather lithologic information, water level data, and fluid samples for chemical analyses. The core holes would also be tested for permeability in accordance with U.S. Bureau of Reclamation test designation E-18. Should contaminants be found on the southerly side of the fault and/or fold feature, an appropriate number of monitoring-extraction wells would be constructed.

TIME SCHEDULE

The estimated times to complete the above outlined tasks are presented on Figure 2, Time Schedule. These are realistic estimates based on performing each task in a planned sequence, allowing for an orderly procedure and the procurement of necessary permits. Time schedules established in the past are meaningless due to such interference.

core hole through
entire upper silt.

-oOo-



SITE CHARACTERIZATION TIME SCHEDULE
(As of May 15, 1984)

Treatment Plant 2

| PROGRAM | May | June | July | August | September | October |
|----------------------------------|-----|------|------|--------|-----------|---------|
| <u>1.0 EXISTING STUDY</u> | | | | | | |
| 1.1 Field Check Mapping | | | | | | |
| 1.2 Core Drilling (5 holes) | | | | | | |
| 1.3 Geologic Sections (12) | | | | | | |
| 1.4 Monitoring Wells (7) | | | | | | |
| <u>2.0 NEW STUDY</u> | | | | | | |
| 2.1 Geologic Mapping | | | | | | |
| 2.2 Test Pits (12) | | | | | | |
| 2.3 Core Drilling (4 holes) | | | | | | |
| <u>3.0 MITIGATION</u> | | | | | | |
| 3.1 Monitoring-Extraction Wells | | | | | | |
| <u>4.0 PREPARATION OF REPORT</u> | | | | | | |

NOTE: Drilling schedule contingent upon availability of 4 core drilling machines and 2 rotary drilling machines.



May 17, 1984

BKK Corporation
2210 Azusa Avenue
West Covina, California 91792

(Our Job No. E-83124-F)

Attention: Mr. Tom Nuckols

Gentlemen:

Liner and Barrier Study Plan
BKK West Covina Landfill

Transmitted herewith is our Liner and Barrier Study Plan, which is being submitted in accordance with DOHS Field Memorandum No. 37, dated May 11, 1984. Due to the short time frame allowed for its preparation, we have not been able to incorporate any of the methodology suggested in Appendix I to the revisions to Subchapter 15 dated April 16, 1984. This appendix presents a "Step-by-Step Guide to Clay Liner-Leachate Compatibility Testing", which is new, and none of our normal analytical laboratory services have any experience with the guidelines.

The required time schedule considers the testing of some of the core holes being drilled for the site characterization study. Therefore, this testing will cause an overlap in the two studies.

Should you have any questions concerning the enclosed plan, please call us.

Respectfully submitted,

LeROY CRANDALL AND ASSOCIATES

by 
Glenn A. Brown, C.E.G. 3
Director of Geological Services

GAB/D59
(25 copies submitted)

LINER & BARRIER STUDY PLAN

BKK WEST COVINA LANDFILL

As requested by the amendments to the Interim Status Document (ISD) and modified in accordance with Field Memorandum Nos. 21, 24 and 37, we are submitting this Liner and Barrier Study Plan. This study plan supersedes our previous plan which was submitted on November 2, 1983. The requirements of the ISD concerning the Liner and Barrier study are listed below:

(i) The amounts of liquid which are able to pass through, under or around Barrier 1 and/or Barrier 2 under all conditions reasonably expected to exist at the land-fill; and

(ii) The extent to which each of the materials, used in Barrier 1 and/or Barrier 2 or relied upon as a liner for the facility to prevent the downward or lateral migration of hazardous waste constituents, are chemically and physically resistant to all those liquids which are reasonably expected to come into contact with those materials; and

(iii) The numerical permeability and attenuation characteristics of each of the materials, used in Barrier 1 and/or Barrier 2 or relied upon as a liner for the facility to prevent the downward or lateral migration of hazardous waste constituents.

ITEM (i)

Why? 7,
In response to (i) above, we submit the following with regard to Barrier 1. We are recommending that the testing of Barrier No. 1 be carried out in the following manner, following a number of preliminary activities.



PRELIMINARY PREPARATION BARRIER 1*Pull casing
or shoot*

1. Abandon existing monitoring wells MW-1A and 1B, MW-2A and 2B, MW-3A, B and C, MW-4A, B and C, MW-5 and MW-9. Each well should be abandoned by injecting a mixture of equal parts of portland cement, bentonite and clear water under the force of gravity until refusal occurs.

*over top
of 3
samples pds
w/ time to
compare.*

2. Discontinue pumping of Barrier No. 1 well MW-8 and well MW-18B until the water levels in these wells approach an equilibrium condition. It is assumed that this condition shall be reached after 4 or 5 days. However, in order to preclude the possibility of contaminated water migrating downgradient from the Barrier, pumping shall be resumed in the event the recovering water level in MW-6B reaches an elevation equal to the elevation of the water level in MW-18B.

3. Provide for the continuous operation of automatic water level recorders in wells MW-20A, B and C, MW-23B and MW-18A.

4. Provide for the continuous recording of the electrical conductivity of effluent from well MW-8.

TEST PROCEDURE

Testing of Barrier No. 1 shall include, but not be limited to the following activities:

- 1) Pump well MW-8 at a constant rate that can be maintained for a 5-day period.
- 2) Collect a water sample from all the above mentioned monitoring wells within two hours after the commencement of pumping for routine chemical analyses.



*Put in piez and
do regular aquifer test
24-48 hr.*

3) Collect water samples from well MW-8 after each 12-hour *why?* interval during the first day of the test, and every 24 hours thereafter.

4) Collect water samples from each well in the vicinity of Barrier No. 1 at the conclusion of the test.

5) Measure static water levels in all wells within one hour prior to the commencement of pumping, including the recently constructed piezometers in the vicinity of the Barrier.

6) Measure water levels in wells MW-6A, 6B, 7, 8, 23A and 24A at each 15-minute interval during the first 2 hours of pumping, on *more in 1st hr* 30-minute intervals during the next 2 hours, on 1-hour intervals during the next 20 hours, and then on 4-hour intervals during the remainder of the test.

7) Measure water levels in the surrounding piezometers at each 12-hour interval throughout the test.

8) Prepare a preliminary report on the results of the Barrier test which shall include:

- a. A physical description of the Barrier, and all associated monitoring wells.
- b. A tabulation of all data obtained during the test.
- c. Hydrographs of wells equipped with automatic water level recorders and drawdown graphs of water level changes in other wells.
- d. A summary of electrical conductivity and chemical analyses obtained during the test.
- e. Conclusions regarding the effectiveness of the Barrier in preventing the downgradient migration of contaminated ground water.



f. Recommendations regarding the continued operation of the Barrier.

It is assumed that recommendations for the continued operation of the Barrier will include the abandonment of wells MW-6A and 6B by grouting. In such case, further testing of the Barrier may be needed to demonstrate its effectiveness.

PRELIMINARY PREPARATION BARRIER 2

The methods employed for the testing of Barrier 2 will be essentially the same as those used at Barrier 1, although the preliminary preparation will require more work.

PRELIMINARY PREPARATION

1) Complete the construction of monitoring wells MW-26, MW-27A, and B, and MW-28.

2) Abandon existing monitoring wells MW-13, 14 and 15. *same as*

3) Repair existing extraction wells MW-10 and 11 which will require the following work:

a. Make a traverse of each well with a 6-inch bailer or 10-foot length of 6-inch pipe to determine plumbness of the well casings.

b. Assuming each well casing is reasonably plumb, bail each well to remove accumulated sludge and redevelop each well by additional bailing.

c. Install 6-inch PVC well screens with 120 0.040-inch horizontal slots per foot in the zone below the water table.

d. Install a 3/4-inch sounding pipe in each well.

e. Determine the continuous pumping yields of MW-10 and 11. *GW*



f. Install a small capacity Grundfoss stainless steel submersible pump in either MW-10 or 11, with appropriate discharge control devices.

g. Install an automatic water level recorder at either MW-10 or 11.

h. Install a pump motor control system that has sufficient flexibility to insure that the extraction well can be pumped continuously, or on a predetermined cyclical basis.

i. Install an automatic conductivity recorder to measure continuously the conductivity of well effluent.

4) Provide for the continuous operation of automatic water level recorders at well MW-17B, MW-26, MW-27A and B, and MW-28.

TEST PROCEDURE

Testing of Barrier 2 shall include, but not be limited to the following activities:

1) Pump well MW-10 at a constant rate that can be maintained for a 5-day period.

2) Collect a water sample from all the above mentioned monitoring wells immediately before or within two hours after the commencement of pumping for routine chemical analyses.

3) Collect water samples from well MW-10 or 11 after each 12-hour interval during the first day of the test, and every 24 hours thereafter.

4) Collect water samples from each well in the vicinity of Barrier No. 2 at the conclusion of the test.



5) Measure static water levels in all wells in the vicinity of the Barrier within one hour prior to the commencement of pumping.

6) Maintain the continuous operation of the automatic water level recorders at wells MW-17B, MW-27, MW-27A and B, and MW-28.

7) Prepare a preliminary report on the results of the Barrier test which shall include:

- a. A physical description of the Barrier, and all associated monitoring wells.
- b. A tabulation of all data obtained during the test.
- c. Hydrographs of wells equipped with automatic water level recorders and drawdown graphs of water level changes in other wells.
- d. A summary of electrical conductivity and chemical analyses obtained during the test.
- e. Conclusions regarding the effectiveness of the Barrier in preventing the downgradient migration of contaminated ground water.
- f. Recommendations regarding the continued operation of the Barrier.

In the event existing monitoring wells MW-13, 14 and 15 are not properly destroyed prior to testing, further testing of the Barrier may be needed to demonstrate its effectiveness.

ITEM (ii)

Item (ii) requires the testing of each of the materials used in Barriers 1 and 2, and the material relied upon as a "liner".



SOIL TESTING

To obtain information on the design and construction of the Barriers, the available reports prepared by Pacific Soils Engineering, Inc. have been studied in detail. Based on the construction details, we plan to locate the site of four boreholes on each barrier. We will also drill three borings in each of the three major lithologic units (lower shale, sandstone, middle shale) to obtain "liner" samples. The borings will be drilled with an 18-inch-diameter bucket auger. Drive samples will be taken of the different materials of those used in the construction of the barrier, with the exception of the gravel. The following laboratory tests will be performed on representative soil samples to obtain data on their physical characteristics.

- o Soil Classified per Unified Soil Classification System (ASTM D 2487)
- o Soil Gradation (Sieve) Test (ASTM D-422) *wing?*
- o Liquid Limit Test (ASTM D-423)
- o Plasticity Index (ASTM D-424)
- o Permeability (ASTM D-3385)
- o Soluble Sulfate (ASTM D-516B)
- o Soil pH (USDA Handbook 60)
- o Soil Expansion Index (Uniform Building Code Standard #29- 2)

Clay materials will be subjected to x-ray diffraction tests to determine their clay mineral composition. This information will be utilized in determining the susceptibility of the clays to base exchange.



The permeability of a soil is that physical characteristic most likely to be affected by change in the chemical composition of the different types of waste fluids.

To investigate the effect of waste fluid on the permeability of the barrier materials and bedrock, we suggest that the U.S. Bureau of Reclamation, Field Permeability Test Designation E-18 and E-19 be utilized for this purpose. The choice of test will be dependent on field conditions.

Boreholes will be drilled to varying depths within a given type of material, and the test performed with clear water. When clear water baseline data has been obtained, the liquid will be changed to those fluids obtained in the vicinity of the barriers. The test procedures will be continued until new permeability data is obtained. The results of the tests will be compared to determine if leachate has an affect on the materials. Three such tests are planned on each soil material and bedrock at each barrier.

FIELD TEST PROGRAM

The method to be used to conduct the infiltration tests is described in U.S. Geological Survey Water Supply Paper 1544-F (1963). The infiltration test method is actually a constant head field permeability test. A constant head of water above the ground surface will be maintained in the cylinder ring throughout the test. A float actuated valve will regulate inflow to the cylinder ring. Water will be conveyed to the ring from two 55-gallon drums. Water level application rates



will be continuously measured by a water level recorder on the supply drums. The method to be utilized to analyze the test data is presented in "Irrigation Principles and Practices" by O.W. Israelson (1963) and in "Earth Manual", a publication by the U.S. Bureau of Reclamation (1960).

It should be noted that the investigation of attenuation, called for in Appendix C to the December 20th Agreement with DOHS, has been presently excluded from the study by Field Memorandum No. 21, dated March 14, 1984.

We propose to conduct a total of nine of the above infiltration test, three in the lower shale unit, three in the sand unit, and three in the middle shale unit. The tests would be conducted in the unweathered zone only.

PRESSURE TESTS

We are currently performing pressure tests on the core holes which are being drilled as part of the site characterization study. We suggest that C-7, when drilled, be utilized as the site of the first pressure test utilizing leachate fluid because of its location away from the property line. As other core holes are drilled for the site characterization study within the central portion of the site, the same procedure of first testing with clear water, then leachate, would be followed.



ITEM (iii)

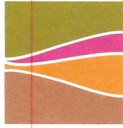
Paragraph (iii) requires the determination of numerical permeability and attenuation characteristics of each of the materials used in the construction of Barriers 1 and 2 and the liner. Permeability data will be derived from the tasks described under Paragraphs (li) and (ii). Both laboratory and in situ tests will be performed and reported upon.

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WORK SCHEDULE
LINER AND BARRIER STUDY PLAN
BKK WEST COVINA LANDFILL

| Task | Month No. 1 (June) | Month No. 2 (July) | Month No. 3 (August) | Month No. 4 (September) | Month No. 5 (October) |
|---------------------------------------------|-----------------------|-----------------------|-------------------------|----------------------------|--------------------------|
| <u>(i) ANALYSES OF BARRIER NOS. 1 AND 2</u> | | | | | |
| 1. Test Barrier No. 1 | _____ | | | | |
| 2. Test Barrier No. 2 | | _____ | | | |
| 3. Analyze Test Data | | _____ | | | |
| <u>(ii) MATERIAL TESTING</u> | | | | | |
| 1. Bucket Auger Drilling | _____ | | | | |
| 2. Laboratory Testing | | _____ | | | |
| 3. Pressure Tests | | _____ | _____ | _____ | |
| 4. Infiltration Tests | | _____ | _____ | _____ | |
| <u>(iii) PERMEABILITY REPORTING</u> | | | _____ | _____ | _____ |



May 17, 1984

Regional Water Quality Control Board
107 South Broadway - Suite 4027
Los Angeles, California 90012

(Our Job No. E-83124-H)

Attention: Mr. Hank Yacoub

Honorable Board Members:

Subsurface Mitigation Plan
BKK West Covina Landfill
West Covina, California

We are herewith transmitting a copy of our "Subsurface Mitigation Plan for the BKK Landfill". Considerable concern has been voiced in the past few months about the hydraulic integrity of the West Covina Landfill. It is the purpose of this plan to lay those concerns to rest so that the design and operation of the facility can be carried out in an efficient manner.

We will appreciate any input or comments you may have after you have reviewed this proposed plan. It is our hope that we can proceed with the plan at the earliest opportunity, as the mitigation measures, when in place, will be of benefit to all concerned. Thank you for your attention in this matter.

Yours very truly,

LeROY CRANDALL AND ASSOCIATES

by

Glenn A. Brown, C.E.G. 3
Director of Geological Services

GAB/D59
(25 copies submitted)

SUBSURFACE MITIGATION PLAN

BKK WEST COVINA LANDFILL

SCOPE

The hydrogeologic studies accomplished to date indicate that there are two areas within the property which exhibit the potential for the movement of fluids outside of the designated waste management areas. The two areas are identified as the sandstone beds upslope from Miranda Street on the southeasterly side of the landfill property (herein called Area A), and in the stream channel upstream from Azusa Avenue in the southwesterly part of the property (herein called Area B). These potential movement areas are shown on Figure 1, Location Map.

In order to mitigate the potential underflow of fluids, we propose the following means of monitoring and controlling the movement of any fluids in each of these two areas.

AREA A

The movement of fluids in a semipermeable medium can be controlled by various means. The injection of a portland cement grout, injection of a chemical grout consisting of two monomers (to make a polymer), the construction of a slurry wall, the creation of a ground water mound, or the maintenance of a pumping trough. The use of injection methods are questionable due to the unknown reactions between the variable composition of leachate and the injected material. A slurry wall has a practical construction depth limit of about 75 feet. The



creation of a ground water mound such as used by Los Angeles County Flood Control District to control sea water intrusion in the West Coast Basin, may be feasible; however, large quantities of water meeting Public Health Drinking Water Standards will be required. Keeping control of the injected water once it is underground becomes another problem, especially in the downgradient direction. A practical and preferred method of control for the BKK Landfill site appears to be the creation and maintenance of a pumping trough.

With the presently known configuration of the sandstone beds at Area A, we are of the opinion that the minimum program would be the construction of four extraction wells. The first well would be situated about 150 feet easterly of Corehole C-3. The remaining wells would be located on approximately 300-foot centers in a southwesterly direction, adjacent to the southeast property line. This configuration would cover 1200 lineal feet of the sandstone outcrop area, which is about 1400 feet in length. The location and construction details of these wells are shown on Sheet 1, "Extraction Well Design". The plan would be to construct the wells to a depth where they penetrate a minimum of 20 feet into the underlying lower shale. Presently available subsurface data suggests that the depths of the wells would range from 450 to about 1000 feet. Once the wells are drilled and tested, it would be determined if they had a measurable pumping effect (drawdown) on the adjacent wells. If not, another well would be drilled on center between the noncommunicative wells, until the well is known to affect its adjacent well or wells.



The wells would be equipped with stainless steel Grundfos pumps. Fluids extracted from the wells would be disposed of by the appropriate on site method, or treated and released to the sewer or a storm drain systems, according to the site Leachate and Other Collected Waters Plan. Each well will be equipped with a totalizing meter or an alternate method of automatically recording well discharge.

The wells in Area A would be monitored daily to determine if they are pumping, and will be measured and fluid samples taken for analysis on a monthly basis. Existing measuring points such as OW-1, C-3, C-4 and MW-29 would also be included in the measuring program.

AREA B

The site for the mitigation of the potential movement at Area B has been located in the topographic constriction about 500 feet easterly of Azusa Avenue. A total of five monitoring-extraction wells are planned for this site. Three shallow wells (about 50 to 60 feet) will be similar to those already constructed at MW-18A and MW-19A. Their primary purpose will be to monitor and control the fluids within alluvial and weathered bedrock materials. Their construction details are shown on Sheet 2, "Shallow and Deep Extraction Wells".

It is the function of the two deep (about 200 feet) monitoring-extraction wells to monitor fluids in the unweathered bedrock zone. Their construction details, which are similar to MW-18B, are also shown on Plate 2.



Should the chemical analyses indicate there is a need to pump any or all of these five wells, fluids extracted from these wells will be disposed of on site by appropriate means, or treated and released to the sewer or storm drain systems.

If required, a pumping trough can be created in either or both shallow and deep zones which would monitor and control the westward migration of fluids originating in the Class I and Class II waste management areas.

INTERNAL FLUID MANAGEMENT

During the course of our field investigations, numerous springs were observed on the easterly side of the "Ephemeral Pond", and in the canyon which contains "Puente Spring". It is considered advisable to control the flow issuing forth from these springs to lessen the quantity of fluids handled in the future at Barrier 1. There may be marked differences in chemical quality which would require less treatment than the fluids at Barrier 1. The appropriate method of controlling the flows appears to be through the use of subdrains. The location of springs and proposed subdrains are shown on Sheet 3. A cross section through a typical subdrain is presented on Sheet 3. The subdrain systems will be connected to a sump located upgradient of Barrier 1.

The long-term objective of internal fluid management within the waste management areas would be to control hydrostatic levels within the existing trash prisms. Provisions for such are outlined in the Leachate and Other Collected Waters Plan.



With the implementation of the mitigation plans for Areas A and B, and the control of spring flows by the use of a system of subdrains, it is our opinion that the BKK Landfill can be isolated, and continue to receive hazardous solid wastes.

-oOo-



**DEVELOPMENT PLAN FOR LANDFILL GAS
CONTROL AND RECOVERY**

4

DEVELOPMENT PLAN FOR LANDFILL GAS CONTROL AND RECOVERY
(LANDFILL GAS PLAN)
BKK CORPORATION

PURPOSE

The primary purpose of this plan is to identify a specific course of coordinated action for the systematic development of management/engineering solutions to requirements for landfill gas migration control and recovery.

BACKGROUND

The disposal of Group II (mixed municipal refuse) began at the BKK West Covina landfill in 1963. It was in 1972 that the site began to receive Group I (Hazardous Materials) Waste. These materials were received only after the construction of a hydraulic barrier was constructed near the Southeastern corner of the site. Today this hydraulic barrier is designated as Barrier #2, (see Exhibit A.)

It was not until 1976 that relatively large quantities of liquids and hazardous waste were received at the site. However, accurate records of refuse weight quantities could not be kept until after scales were installed in 1978.

From volumetric estimates calculated from topographic cross sections through the landfill, it is believed that approximately 6 million tons of solids and liquids were deposited between the years 1963 to 1980. It is estimated that by 1986 that there will be 14 million tons of refuse in place.

By using the estimated in-place tonnage up to and including in-place tonnage deposited in 1983 and entering this data in a gas prediction model, it can be projected that approximately 4 - 5 million cubic feet per day of methane are currently being produced. In the late part of 1983 significant activities were undertaken by BKK, in cooperation with the Department of Health Services, to characterize the geology and hydrology of the West Covina landfill site. As a result of these activities, data was found which could indicate that landfill gas was in contact with liquids in and around the landfill.

In January, 1984, Mandeville & Associates was retained by BKK to prepare a landfill gas development plan which would mitigate potential problems associated with landfill gas migration. In addition, this plan was to closely interphase with geotechnical activities already in progress to help insure the Class I integrity of the site.

OBJECTIVES

The objectives of this plan fall into the following categories. In order of priority they are:

1. Prevention of subsurface migration of landfill gas. Subsurface migration includes both on-site migration and off-site migration. The plan seeks to address measures, when implemented would mitigate on-site gas migration-borne contaminants from coming in contact with sub-surface liquids. In addition, the plan addresses concerns of possible off-site gas migration mitigation measures.
2. Prevention of surface migration of landfill gas. Specific tasks in the plan employ methods, when implemented, will help alleviate environmental concerns of surface migration of landfill gas.
3. Prevention of volatile organics from leachate or condensate from venting to atmosphere in an uncontrolled manner.
4. Creation of policies and procedures for the control of landfill gas venting during excavation of the landfill for the purpose of either modifying the existing collection system or for the purpose of expansion of the gas collection system in new areas.
5. Develop engineering plans and designs for the eventual installation of a landfill gas recovery and electrical generation project.

PROGRAM TASK SCHEDULE

There are seven major task headings below. Sub-tasks are not shown broken out in this phase of developing the landfill gas plan, but are described in narrative form under each major task heading. Also included with the major task headings are estimated completion dates. It should be noted that some sub-tasks will overlap into other major task headings, as some sub-tasks could be included in more than one major task heading.

Task I Data Gathering (Completion Date 6-1-84)

Purpose:

No research effort is complete without a thorough understanding of the facts and data that have already been gathered. Task I seeks to verify or modify previous conclusions through independent observation of the data.

Description:

During this task, all previously published data on tonnages of refuse of liquid hazardous waste will be closely examined. In addition, volumetric estimates taken from cross sections made on topographic maps from the years 1963 - 1984 will be made. These estimates, when converted from cubic yards to tons of refuse will give further information on placement of refuse, its depth, areas of influence by the current gas collection system, the location, and configuration of an expanded gas collection system.

Once the relative refuse chronology has been established for the years 1963 - 1984, this data will be entered into Mandeville & Associates gas production model.

This model simulates, over time, the quantities of landfill gas (as pure methane, see Exhibit B) that could be expected over the production life of the West Covina Landfill. After reviewing and reducing of field data taken on site, the actual data or methane quality and flow rates will be fed back into the model to adjust the results for real-time data.

Once the shape of the curve has been "fitted" to historical and present data, estimates on future quantities of refuse and liquids may be entered into the model to predict future quantities of landfill gas.

It is understood that the current solidification program now underway at BKK West Covina will not be co-mingling Group II Municipal Refuse with Group I Hazardous Waste in the "Designated Disposal Area for Group I Wastes" within the permitted Group I area. The fact is there will be little or no organics placed in this area which will have a slowing effect upon the future gas generation rates. Preliminary well designs (see Exhibit A), for the expansion of a gas collection system into the area have taken this uncertainty into account.

Task 2

Air Quality Mitigating Measures (Completion Date 6-1-84)

Purpose:

The efforts outlined in this task relate to Objectives #1, #2, and #4 and seek to address three areas of concern where landfill gas may be migrating horizontally, as in possible contamination of leachate water collected by various water monitoring wells throughout the site, or vertically, in cases where there is insufficient influence in the existing collection system; lack of any collection system at all, in areas where there is refuse in place, but as of yet no system to collect the gas (North of Barrier #1, Group II Waste Area); open or improperly sealed water monitoring wells, cores and gas collection wells.

Description:

Procedures are proposed that will insure that all open holes, wells, broken lines, fractures, ground cracks, that would allow landfill gas to escape uncontrolled to the atmosphere be closed, covered or repaired within 24 hour period. Furthermore, it is recommended that formal inspection of the landfill site by an authorized staff of BKK be conducted at least twice a month.

Additionally, it is proposed that a flare be designed capable of incinerating 2500 CFM (1500°F, draw time of 0.4 sec) be connected to a 2000' leach line between Barrier #1 and Barrier #2.

Water monitoring wells in the vicinity of Barrier #1 and #2 are proposed to be tied into a main header line connected to what is now branch line "B", (see Exhibit A.)

It is further anticipated that a perimeter gas migration control system will be needed immediately, once water monitoring wells in the "C" section near the access road adjacent to bench "A" and "B" are located and drilled by BKK's consulting geologist, LeRoy Crandell and Associates. Expectations are that four gas migration control probe/wells will be installed, one for every water monitoring well. If needed, these gas collection probe/wells maybe connected to header line "F", if active control is needed, (see Exhibit C and Drawing Detail C-1.)

In conjunction with any and all drilling or excavating to be done on the landfill, appropriate air pollution control devices will be in use with drilling equipment. However, prior to any drilling taking place (emergencies excepted) on the landfill, appropriate permits to construct will be sought from the South Coast Air Quality Management District. The permits to construct applied for, however, will be made as "blanket" permits for several wells at one time, so as to allow construction to proceed in as an expeditious manner as possible.

Task 3

Modify/Expand Existing Gas Collection System (Completion Date 7-1-84)

Purpose:

This is the formal design and engineering of modifications and/or expansions of the existing system necessary based upon gas production curves generated from tonnage data gathered in Task 1. This is the implementation of Objectives #1 and #2 described above.

Description:

This task is the formal engineering design of the expanded and/or modified existing landfill gas system. Its primary objective will be to serve as a gas migration control system, the secondary objective will be to serve as a gas delivery system, for a gas turbine electrical generation project to be located on site. As part of this task, a model to determine header line sizing will be used. This is to insure that adequate vacuums at proposed well heads are present so that the rates of flow from each well has sufficient "zone overlap" as to control any surface and subsurface migration.

The expansion of the collection system will take place in three phases. In Phase I, it is proposed that a horizontal collection system be installed throughout the remainder of the Class I permitted area, (see Exhibit A.) It is proposed that several 1500' trenches, approximately 5' deep, having 10" slotted PVC pipe placed in the trenches and backfilled with 2" crushed rock. The trenches are designed at 300' intervals. Each trench will have a 3% slope designed for leachate and condensate drainage. The liquid will collect in sumps at each end of a trench line and will be pumped out into a leachate treatment facility for ultimate disposal when necessary, (see Exhibit A and Drawing Detail A-1, A-2 and A-3.)

It is expected that each horizontal trench will have a vertical zone of influence of about 30' to 40'. If after the completion of a 30' lift of refuse material over the trenches, it is determined that the installed trench wells are no longer effective in controlling surface migration, a second set of trench wells may be installed above the first set.

As part of the Phase I effort, it is proposed that gas monitoring probes be installed along the Southern and Western property boundaries adjacent to the residential areas, (see Exhibit A.) These probes will be installed in accordance with the Los Angeles City Bureau of Sanitation requirements for probes to be placed every 300' at a depth of 30', and every 600' a probe shall be placed at a depth equal to the bottom of the fill. Consideration will be made on the possible installation of triple probes every 300' as shown in Detail Drawing A-4. These probes would be installed in a cluster having one shallow probe at 30', one deep probe to be installed at the bottom of the landfill and one halfway between.

A Phase II effort would expand the Phase I collection system to include the Group II material located North of Barrier #1. As part of this effort would be the location of gas monitoring probes and/or L.E.L. detectors in or near buildings, located on the site; the location of the gas monitoring probes along the Northern property line at 300' intervals, similar to that of the probes described above, (see Exhibit A.)

Phase III would be an landfill gas evaluation program which would propose changes in response to the dynamic changes in the landfill. This would include in part, monitoring programs described later.

Task 4

Evaluate Motor Blower Flare Station (Completion Date 6-1-84)

Purpose:

This task is designed to perform tests on the motor blower/flare stations against the manufacturer's specifications to determine existing capacity and optimum operating conditions for each blower and flare. The results of this task will be used to determine if additional blower/flare units are needed for the expanded system. This task will also address the flare needs of a gas recovery project as outlined in Objective #5.

Description:

The efforts outlined in this task will include evaluation of actual blower performance compared to manufacturer's performance curves. Based upon results, a recommendation will be made on capacity reserves as well as optimum operating conditions.

Excess capacity of the blowers will be compared to the requirements for gas flow as proposed in Phase I, Task 3. Recommendations on operations, modifications or replacements will be made prior to final design of expanded well collection system.

As part of the blowers performance effort, flare inlet and exit gases will be analyzed to determine flare efficiencies.

Task 5

Preparation of Operating Procedures (Completion Date 7-15-84)

Purpose:

To develop standard procedures for data gathering, instrument calibration and system operations. This task ties in with, Phase III, Task 2 and 3, as well as Objective #2.

Description:

The procedures developed in this task will help insure that minimum standards are met with regard to gathering field data, monitoring installed gas probes, data reduction, data analysis and review. These procedures will also set criteria for adjustment, operation of wells, blowers and flare equipment.

These procedures will be detailed in an O&M manual. Also included in this manual will be scheduled maintenance requirements for all pieces of major equipment. It will include detailed descriptions of operation, troubleshooting techniques and lubrication schedules.

Task 6

Landfill Gas Recovery Engineering Services (Completion Date 8-1-84)

Purpose:

To provide the interface between the landfill gas collection recovery system and the landfill gas requirements of an electrical generating gas turbine(s). This is an expansion of Objective #5 and of Tasks 2 and 3.

Description:

This task requires engineering to determine the compatability of the existing gas collection with the proposed electrical generating gas turbine(s). This evaluation contains several elements including the gas pretreatment process design; engineering design for the disposal of the condensate.

It is also anticipated that there will be a requirement for a new flare station in conjunction with the described recovery project. It will be part of this task to design a new flare station.

Task 7

Leachate Treatment Engineering (Completion Date 8-1-84)

Purpose:

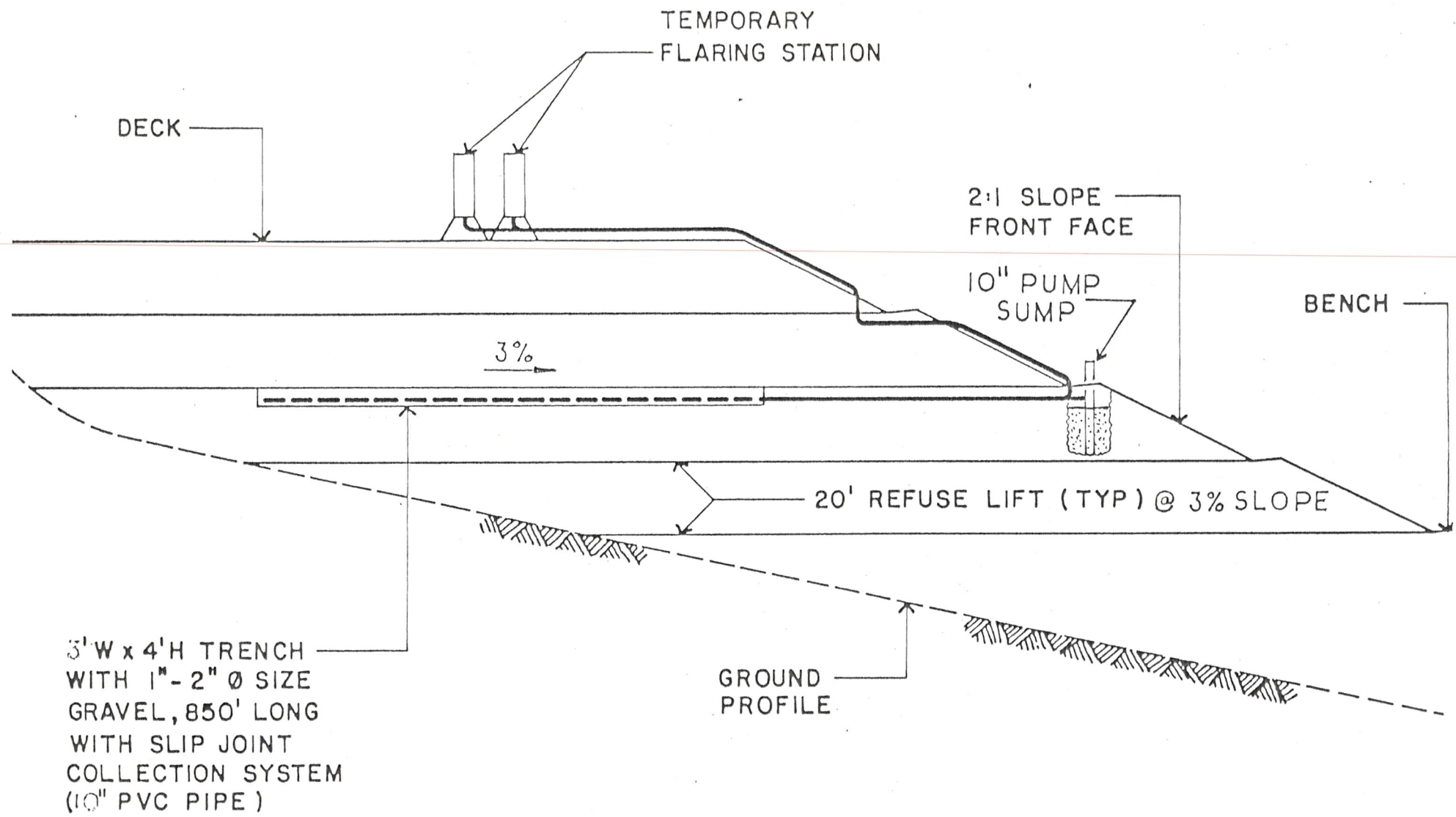
The primary objective of this task is to find a feasible alternative for leachate disposal. It follows onto the design efforts of Task 3 and meets the requirements of Objective #3.

Description:

Since leachate from the landfill has various degrees of contamination, some of which needs to be treated before disposal, a pilot air stripping project has been proposed to see if contaminants can be removed to safe levels for proper disposal.

If the system operates as designed, an expanded system will be proposed and designed. With the new design would be the preparation of an O&M manual for the liquid extraction system.

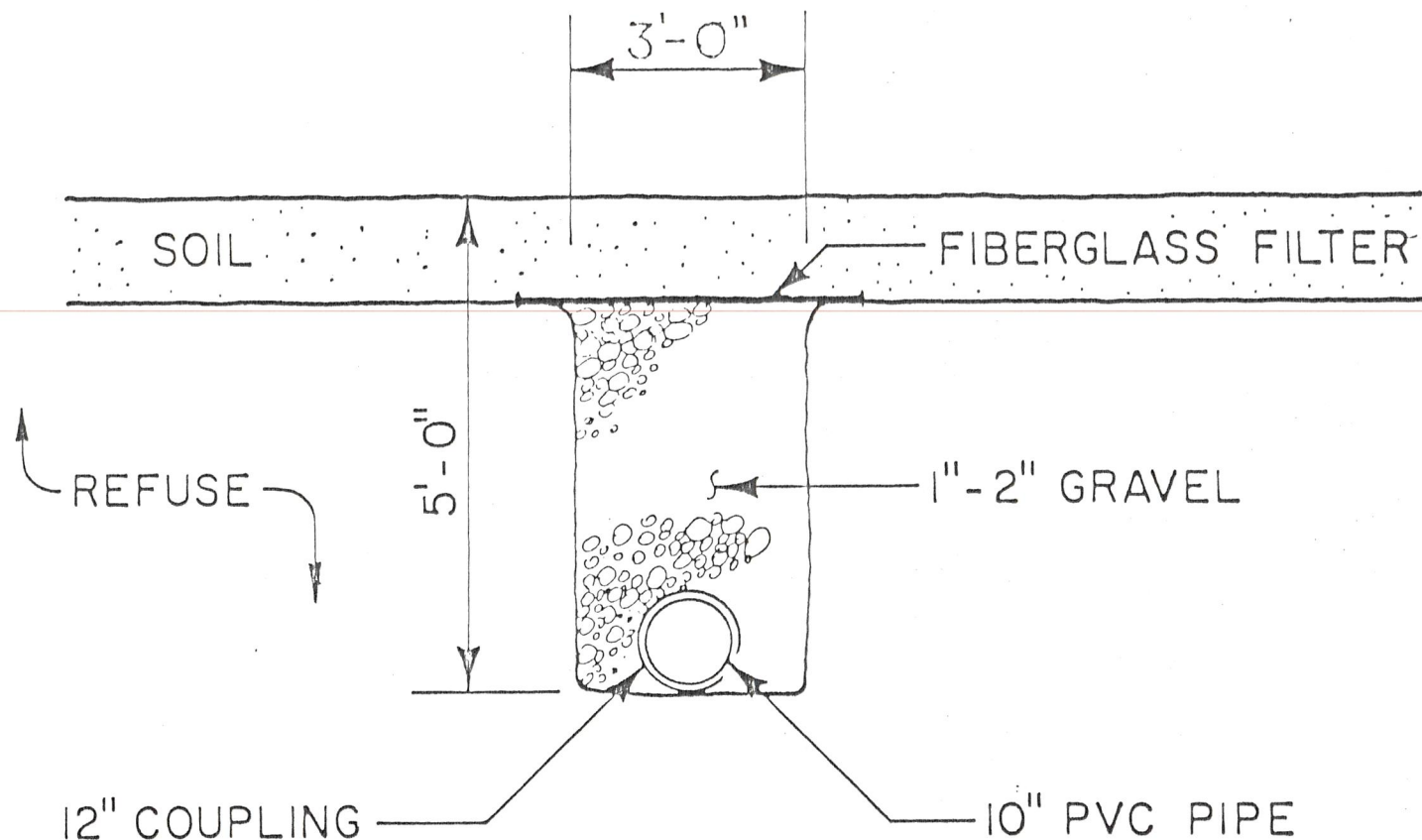
DRAWING DETAIL A-1



PROFILE ALONG LENGTH OF TRENCH

MANDEVILLE & ASSOCIATES Energy Recovery Services
550 North Rosemead Boulevard, Suite 201, Pasadena, CA 91107
213/351-5502

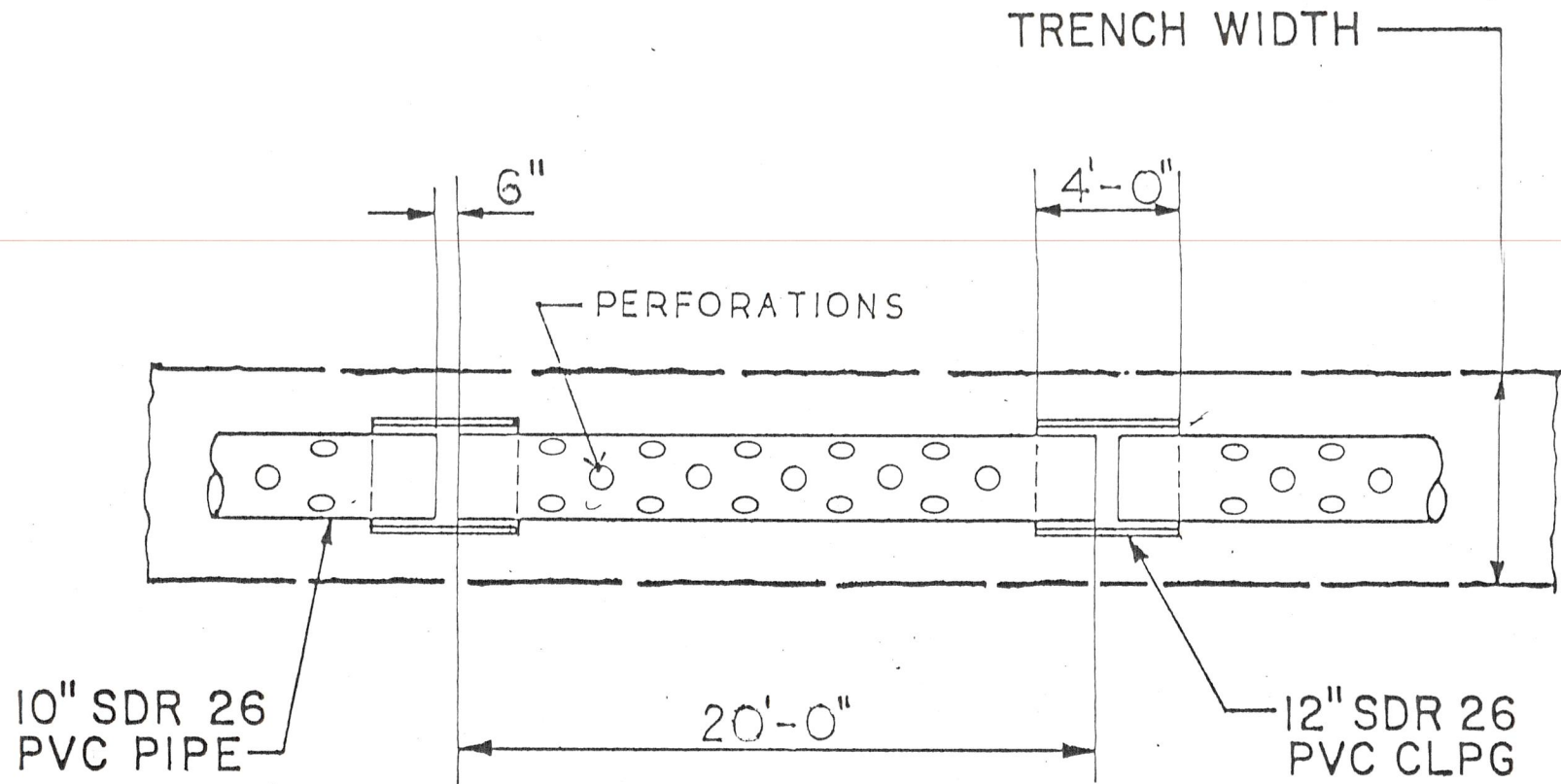
WEST COVINA, CALIFORNIA
BKK LANDFILL



CROSS SECTION OF HORIZONTAL TRENCH

MANDEVILLE & ASSOCIATES Energy Recovery Services
550 North Rosemead Boulevard, Suite 201, Pasadena, CA 91107
213/351-5502

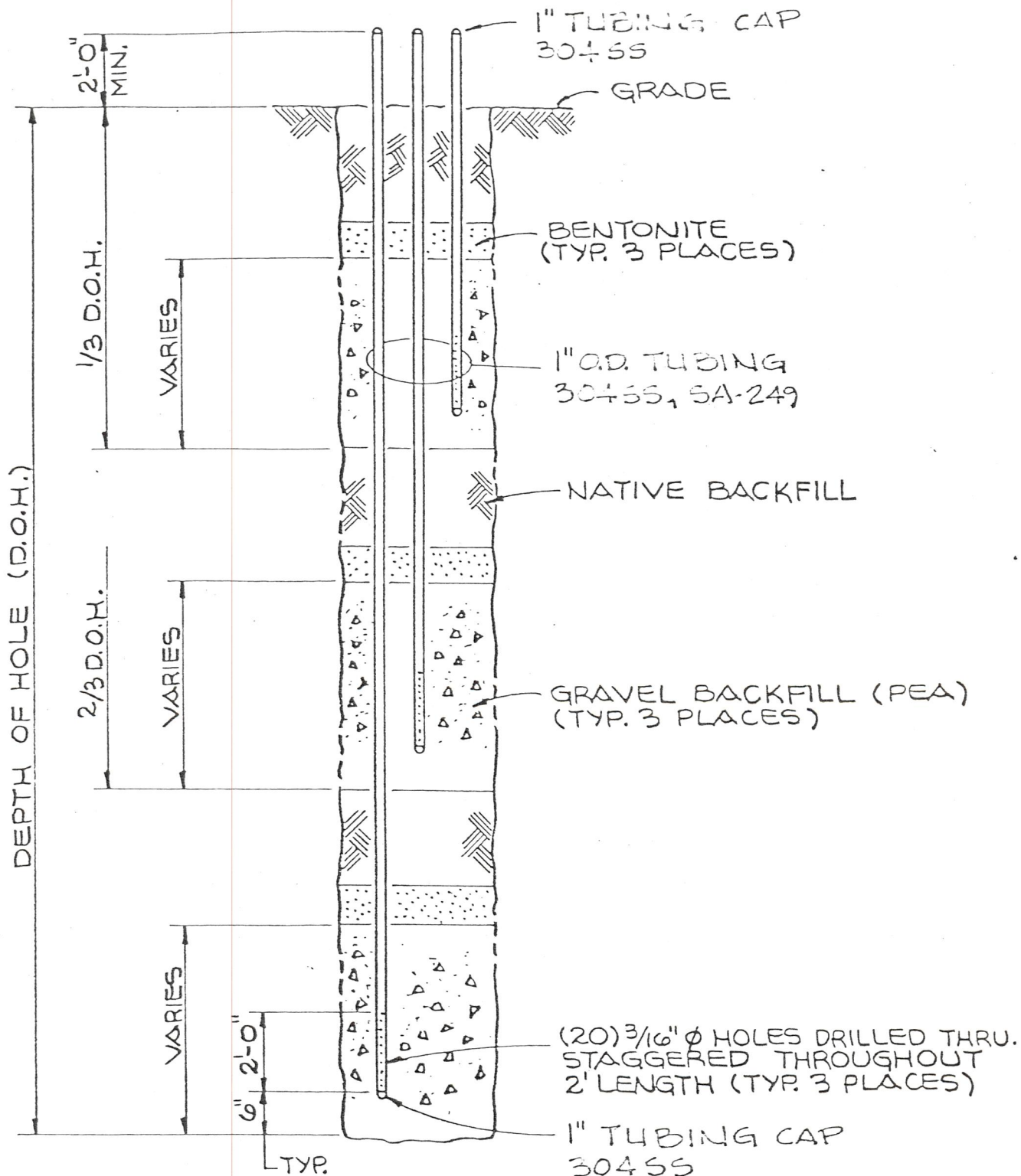
WEST COVINA, CALIFORNIA
BKK LANDFILL



PLAN VIEW OF HORIZONTAL TRENCH PIPING

MANDEVILLE & ASSOCIATES Energy Recovery Services
550 North Rosemead Boulevard, Suite 201, Pasadena, CA 91107
213/351-5502

WEST COVINA, CALIFORNIA
BKK LANDFILL



MANDEVILLE & ASSOCIATES Energy Recovery Services
550 North Rosemead Boulevard, Suite 201, Pasadena, CA 91107
213/351-5502

SCALE: NONE

APPROVED BY:

DRAWN BY b9

DATE: 2-9-83

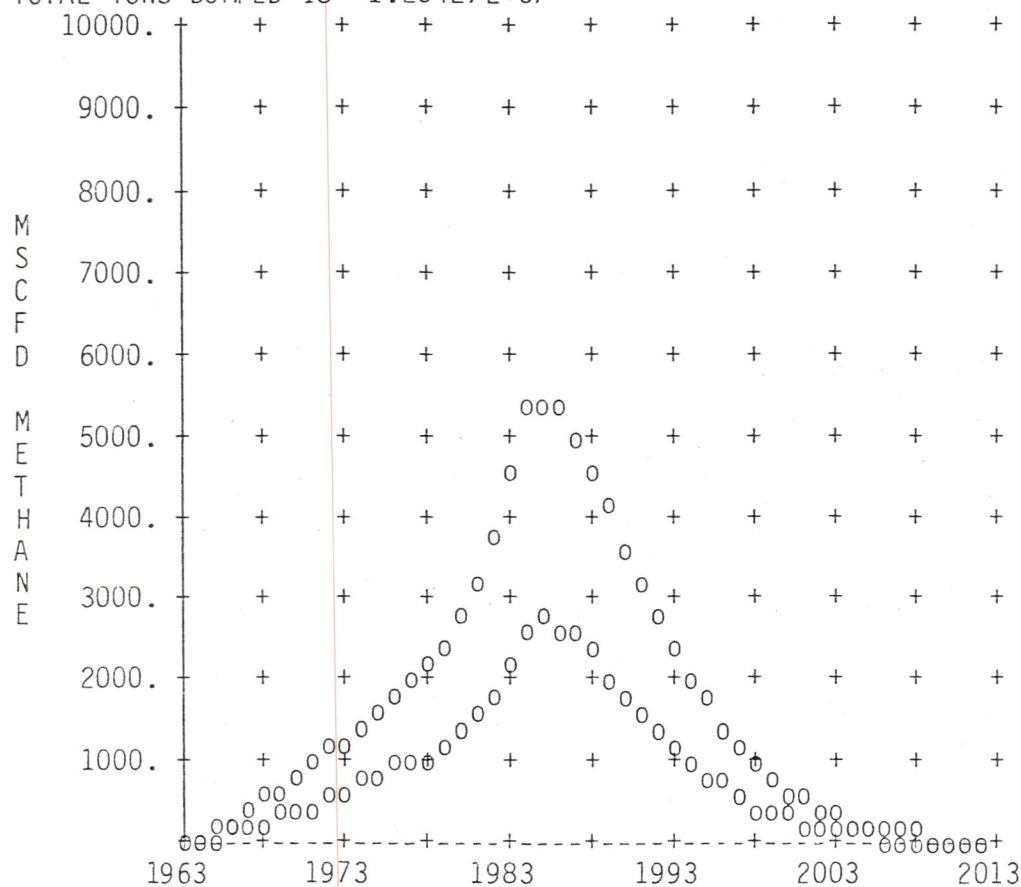
REVISED

TYPICAL MULTIPLE PROBE DETAIL

WEST COVINA, CALIFORNIA
BKK LANDFILL

DRAWING NUMBER
A-810-31-0002

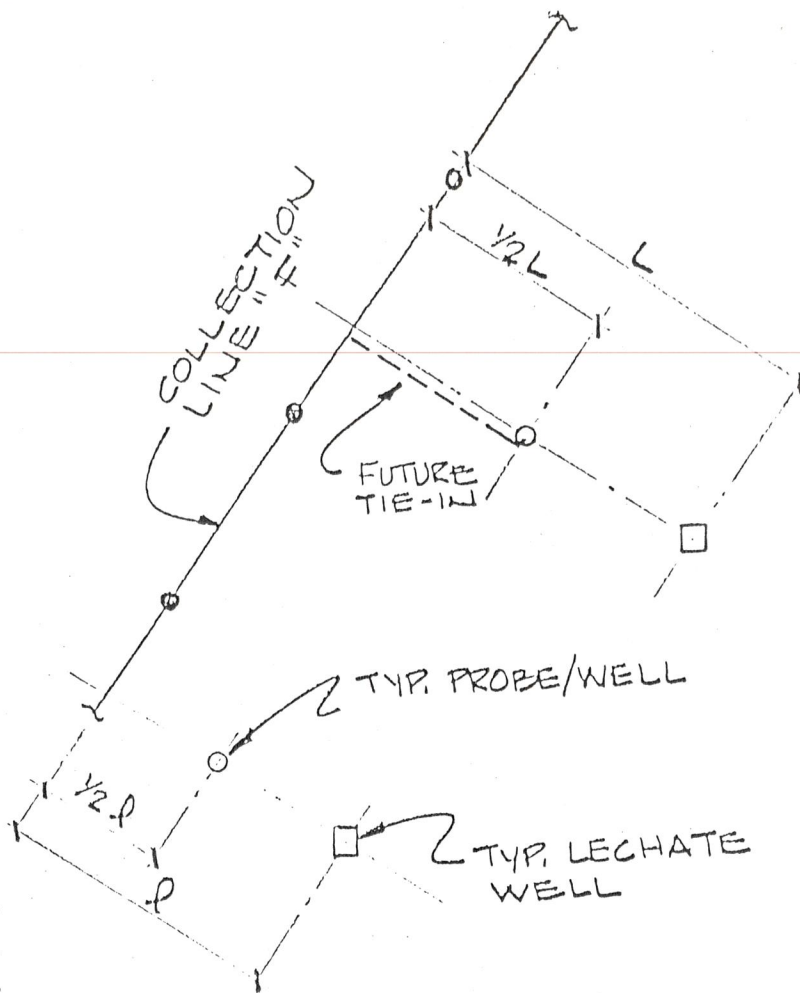
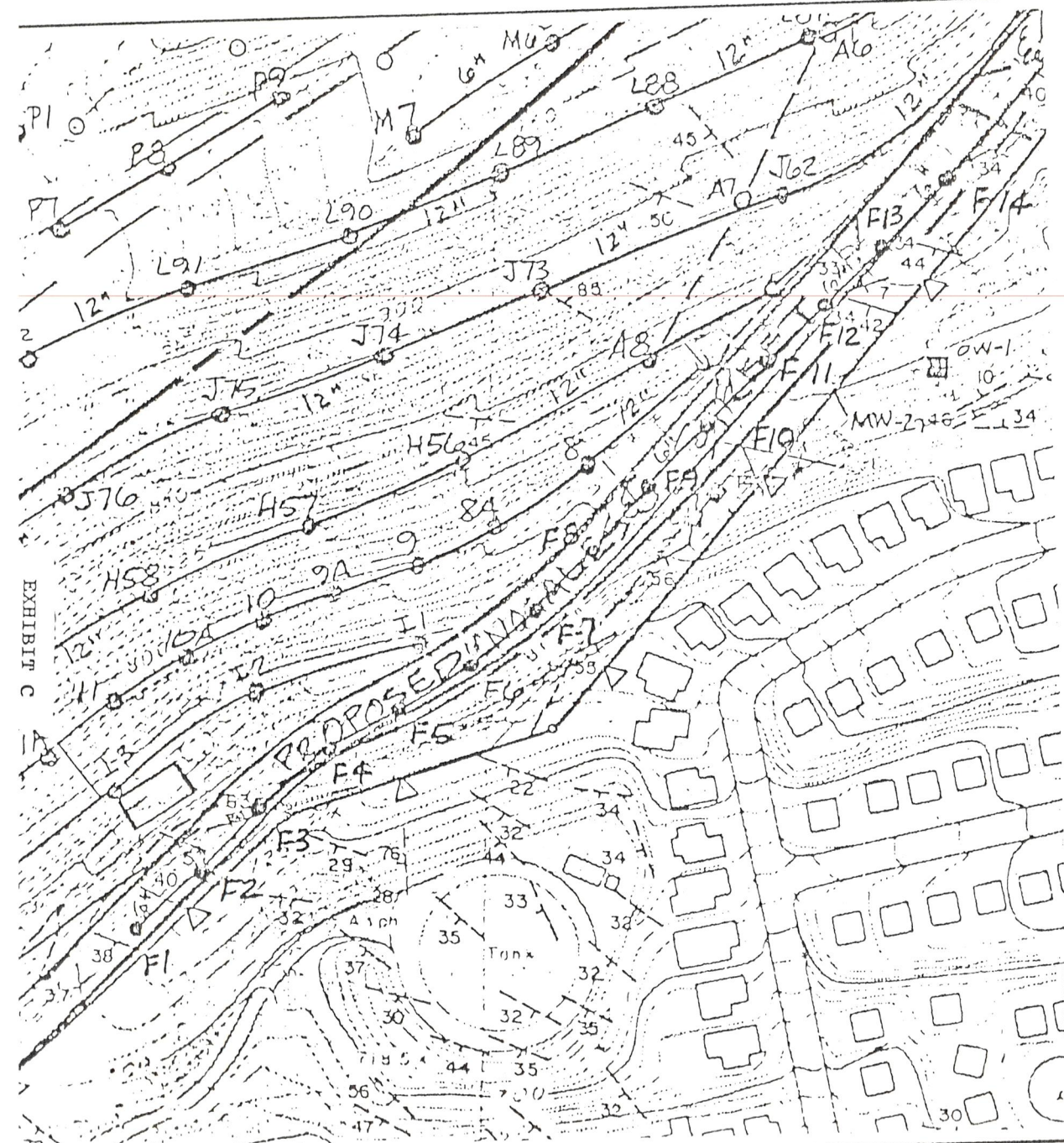
TOTAL TONS DUMPED IS 1.20427E+07



LANDFILL NAME IS ''BKK''
 FILENAME DATA IS STORED UNDER IS ''BKKLANDF''
 THEORETICAL METHANE YIELD USED IS 1.3 SCF/# OF WET REFUSE
 PERCENT OF METHANE RECOVERABLE= 50 %
 RATE OF DECOMPOSITION FACTOR = 100 0 IS SLOW 100 IS VERY FAST
 P1= 5 P2= 25 P3= 70
 TOTAL TONS DUMPED IS 1.20427E+07

| | | | |
|-----------------------------------------|--------------|-------------------|---------------|
| % COMPOSITION OF GAS PRODUCING MATERIAL | FAST 5.00 | MODERATE 25.00 | SLOW 70.00 |
|-----------------------------------------|--------------|-------------------|---------------|

| METHANE GENERATED IN MSCFD | | | METHANE GENERATED IN MSCFD | | |
|----------------------------|---------|-------------|----------------------------|---------|-------------|
| YEAR | MSCFD | TONS(000'S) | YEAR | MSCFD | TONS(000'S) |
| 1963 | 0.00 | 154.14 | 1988 | 4606.81 | 0.00 |
| 1964 | 63.84 | 169.56 | 1989 | 4156.26 | 0.00 |
| 1965 | 153.84 | 186.51 | 1990 | 3694.43 | 0.00 |
| 1966 | 262.58 | 205.17 | 1991 | 3242.07 | 0.00 |
| 1967 | 384.56 | 225.68 | 1992 | 2812.88 | 0.00 |
| 1968 | 516.41 | 248.25 | 1993 | 2415.59 | 0.00 |
| 1969 | 656.27 | 273.07 | 1994 | 2055.21 | 0.00 |
| 1970 | 803.30 | 300.38 | 1995 | 1733.88 | 0.00 |
| 1971 | 957.36 | 330.42 | 1996 | 1451.61 | 0.00 |
| 1972 | 1118.84 | 363.46 | 1997 | 1206.86 | 0.00 |
| 1973 | 1288.54 | 399.81 | 1998 | 997.06 | 0.00 |
| 1974 | 1467.62 | 439.79 | 1999 | 819.03 | 0.00 |
| 1975 | 1657.55 | 483.77 | 2000 | 669.31 | 0.00 |
| 1976 | 1860.04 | 400.00 | 2001 | 544.39 | 0.00 |
| 1977 | 2022.31 | 486.67 | 2002 | 440.89 | 0.00 |
| 1978 | 2198.12 | 593.33 | 2003 | 355.70 | 0.00 |
| 1979 | 2408.79 | 800.00 | 2004 | 285.95 | 0.00 |
| 1980 | 2706.14 | 1066.67 | 2005 | 229.15 | 0.00 |
| 1981 | 3132.64 | 1533.33 | 2006 | 183.09 | 0.00 |
| 1982 | 3786.08 | 1666.67 | 2007 | 145.90 | 0.00 |
| 1983 | 4557.98 | 1716.00 | 2008 | 115.98 | 0.00 |
| 1984 | 5380.03 | 0.00 | 2009 | 92.00 | 0.00 |
| 1985 | 5484.38 | 0.00 | 2010 | 72.82 | 0.00 |
| 1986 | 5331.37 | 0.00 | 2011 | 57.53 | 0.00 |
| 1987 | 5014.62 | 0.00 | 2012 | 45.38 | 0.00 |



NOTE:

- 1... ALL LECHATE WELLS TO BE FIELD LOCATED BY LEROY GRANDELL (L.C.A.)
- 2... ALL PROBE/WELLS TO BE FIELD LOCATED MIDWAY BETWEEN LECHATE WELLS AND COLLECTION LINE "F".

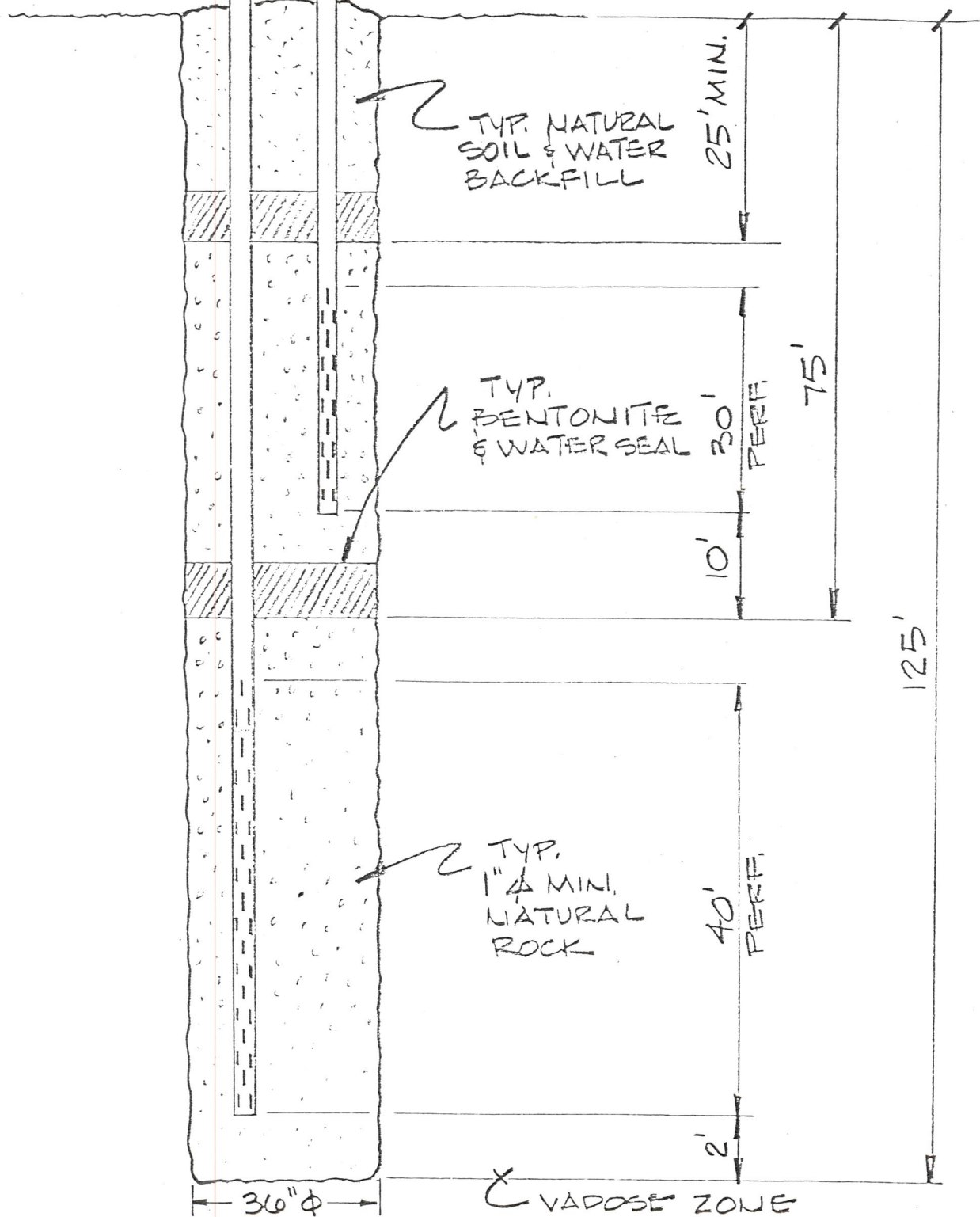
TAG: PW-

DEEP
PROBE

SHALLOW
PROBE

NOTE:

PROBE/WELL CASING
MAY BE 4" OR 6" ϕ



MANDEVILLE & ASSOCIATES

Energy Recovery Services

TYPICAL PROBE/WELL
INSTALLATIONS

**MANAGEMENT PLAN
FOR DISPOSAL OF LEACHATE AND
OTHER COLLECTED SITE WATERS**

5

**SAMPLING PROTOCOLS FOR GROUNDWATER,
SURFACE WATER, STANDING LIQUID, SEDIMENT,
SURFACE SOIL AND SUBSURFACE SOIL**

6

1.0 GROUNDWATER

1.1 The importance of proper well construction, development and sample collection cannot be overemphasized. Construction and development of collection wells as well as sample collection techniques must comply with the following:

1. Manual of Groundwater Sampling Procedures, The Robert S. Kerr Environmental Research Laboratory, U. S. EPA, May, 1980.
2. Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities, U. S. EPA, EPA-530/SW-611, August, 1977.
3. Manual of Water Well Construction Practices, U. S. EPA, Office of Water Supply, EPA-570/9-75-001.
4. Water Well Standards: State of California, California Department of Water Resources, Bulletin 74-81, December, 1981.

The type of sample collection method employed will depend on the type and depth of well, as well as the analytical requirements. The sampling equipment must not alter or contaminate the sample.

1.2 Sample Withdrawal Methods

Sample withdrawal methods include the use of pumps, compressed air, bailings, and samplers. The primary consideration is to obtain a representative sample of the ground-water body by guarding against mixing the sample with stagnant (standing) water in the well casing. In a non-pumping well, there will be little or no vertical mixing of the water; and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Persons sampling should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface, resulting in unrepresentative data and misleading interpretation of the same.

To safeguard against collecting non-representative stagnant water in a sample, the following guidelines and techniques should be adhered to during sample withdrawal:

As a general rule, all monitoring wells should be pumped or bailed prior to withdrawing a sample. Evacuation of a minimum of one volume of water in the well casing and preferably three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

Advantages:

1. It can be constructed with a variety of materials compatible with the parameter of interest.
2. Economical and convenient enough that a separate bailer may be dedicated to each well to minimize cross contamination.
3. No external power source required.
4. Low surface to volume ratio reduces outgassing of volatile organics.

Disadvantages:

1. Sometimes impractical to evacuate stagnant water in a well bore with a bailer.
2. Transfer of water sample from bailer to sample bottle can result in aeration.
3. Cross-contamination can be a problem if equipment is not adequately cleaned after each use.

1.2.2 Suction Lift Pumps

There are a variety of pumps available that can be used when the water table is within a suction lift, i.e., less than about 20 feet. Centrifugal pumps are the most commonly available, are highly portable and have pumping rates from 5 to 40 gpm. Most of these require a foot-valve on the end of the suction pipe to aid in maintaining a prime.

Peristaltic pumps are generally low-volume suction pumps suitable for sampling shallow, small diameter wells. Pumping rates are generally low but can be readily controlled within desirable limits. One significant limitation is the low pumping rates used initially to flush out the well bore. Another limitation is that electrical power is required. Hand operated diaphragm pumps are available that can be operated over a wide range of pumping rates which facilitates rapid evacuation of a well bore initially and lower controlled pumping rates for subsequent sampling. One major advantage is portability.

Advantages:

1. Generally, suction lift pumps are readily available, relatively portable, and inexpensive.

Disadvantages:

1. Sampling is limited to ground water situations where water levels are less than about 20 feet.
2. May result in degassing and loss of volatile compounds.

Advantages:

1. Portable-ac power not required.
2. Constructed of noncontaminating, nonadsorbing materials.
3. Variable flow rates up to 45 gals/hr are obtainable.
4. Can be used in well casings with minimum diameters of about two inches.

Disadvantages:

1. Requires high purity nitrogen gas.
2. Glass construction is somewhat more fragile than other materials.
3. Stripping of CO₂ from water may be a problem for pH sensitive parameters.
4. Gas stripping of volatile compounds may occur.

1.2.6 Gas-Operated Squeeze Pump

These systems consist principally of a collapsible membrane inside a long, rigid housing, compressed gas supply and appropriate control valves. When the pump is submerged, water enters the collapsible membrane through the bottom check valve. After the membrane has filled, gas pressure is applied to the annular space between the rigid housing and membrane, forcing the water upward through a sampling tube. When the pressure is released, the top check valve prevents the sample from flowing back down the discharge line, and water from the well again enters the pump through the bottom check valve.

Advantages:

1. Wide range in pumping rates are possible.
2. Wide variety of materials can be used to meet the needs of the parameters of interest.
3. Driving gas does not contact the water sample, eliminate possible contamination or gas stripping.
4. Can be constructed in diameters as small as one inch - permits use of small economical monitoring wells.
5. Highly portable.

Disadvantages:

1. Large gas volumes and long cycles are necessary for deep operation.
2. Pumping rates cannot match rates of submersible, suction or jet pumps.
3. Commercial units relatively expensive - approximately \$1000 for units currently available.

The most commonly employed sample containers are 40 ml glass vials for analyses requiring small sample volumes, such as total organic carbon, and one-gallon jugs for analyses requiring relatively large volumes, such as extractable organics. Both types of containers are equipped with Teflon-lined screw caps. Like all glassware used in the sampling and analytical procedures, sample containers are thoroughly cleaned prior to use by washing with detergent, rinsing extensively with tap water followed by high purity deionized water and heating to 560° for two hours.

Grab samples of groundwater to be analyzed for high volatile organics by the Bellar-Lichtenberg volatile organic analysis (VOA) method are usually obtained by means of a Teflon bailer. Use of the systems described previously is less desirable than bailers for VOA samples because of the possible stripping of highly volatile constituents from the sample under the reduced or elevated pressure occurring in systems using pumps.

1.3.2 Continuous Procedures

Continuous procedures, using selected adsorbents to concentrate and recover organic constituents from relatively large volumes of ground water, may be employed for sampling organic pollutants in situations where the analytical sensitivity and sample uniformity attainable by grab sampling are inadequate. These procedures are applicable for most organic pollutants except those of very high volatility.

Sampling is conducted by continuously pumping ground water through a adsorbent column sampling systems at flow rates usually ranging from 10 to 30 ml/min. The volumes sampled are dependent on the desired sensitivity of analysis. For analysis by modern gas chromatograph techniques, sampling of 50 liters of water is sufficient to provide a sensitivity of at least one ug/liter (1 ppb) for almost all compounds of interest. Volumes sampled are determined by measuring the water leaving the sampling systems in calibrated waste receivers.

1.3.3 Volatile Organics in the Unsaturated Zone

For investigations pertaining to organic pollution of ground water, it is often desirable to sample water in the unsaturated zone to detect and follow the movement of pollutants that are migrating toward the water table. This is a particularly difficult task in the case of highly volatile compounds, including the low molecular weight chlorinated hydrocarbons such as trichloroethylene. A number of these compounds are widely used and released into the environment in significant quantities, exhibit some form of toxicity, particularly carcinogenicity, and are being increasingly implicated in cases of ground water pollution.

Soil-water samples may be collected using the device which consists of a sampler, a purging apparatus, and a trap connected to sources of nitrogen gas and vacuum. The soil-solution sampler consists of a 7/8 in. O.D. (2.2 cm) porous ceramic cup, a length of 3/4 in. O.D. Teflon or PVC pipe and a Teflon stopper fitted with 3 mm O.D. Teflon exhaust and collection tubes. The length of the pipe is dictated by the depth of sampling desired, which is limited to a maximum of about 20 feet. The device is basically a suc-

3.1 Trowel or Scoop

A garden-variety trowel looks like a small shovel (Figure 4). The blade is usually about 7 by 13 cm (3 by 5 in.) with a sharp tip. A laboratory scoop is similar to the trowel, but the blade is usually more curved and has a closed upper end to permit the containment of material. Scoops come in different sizes and makes. Stainless steel or polypropylene scoops with 7 by 15 cm (2 3/4 by 6 in.) blades are preferred. A trowel can be bought from hardware stores; the scoop can be bought from laboratory supply houses.

Uses--

An ordinary zinc-plated garden trowel can be used in some cases for sampling dry granular or powdered materials in bins or other small containers. The laboratory scoop, however, is a superior choice. It is usually made of materials less subject to corrosion or chemical reactions, thus lessening the probability of sample contamination.

The trowel or scoop can also be used in collecting top surface soil samples.

Procedure for Use--

1. At regular intervals (see Section 6), take small, equal portions of sample from surface or near the surface or the material to be sampled.
2. Combine the samples in a suitable container.
3. Cap the container; attach the label and seal; record in field log book; and complete sample analysis request sheet and chain of custody record.
4. Deliver the sample to the laboratory for analysis.

4.0 SUBSURFACE SOIL

As with ground water samples, successful sampling of subsurface earth solids requires both acquisition of cores of subsurface solids at desired depths in a manner minimizing potential contamination and proper handling and processing of the core material obtained to insure its integrity and produce samples suitable for determinative analytical procedures.

There are a variety of procedures and equipment that have been used to collect earth materials for classification and identification of physical characteristics. The most common procedures use a thin-wall steel tube (core barrel) which is forced into the undisturbed soil at the bottom of a bore hole. This is sometimes referred to as drive sampling. Core barrels are generally from one inch to three inches in diameter and 12 to 24 inches long. When the core barrel is retrieved, friction will usually retain the sample inside, at least in most unsaturated materials.

4.1 Handling and Processing of Core Materials

The procedures to follow in processing a sample will depend on the type of analyses and the situation in the field. Regardless of the types of analyses to be performed, processing should be as soon as possible.

Split tubes or sectioned tubes are sometimes used to collect cores so as to permit access to the core material with minimal disturbance. Alternately, a single piece coring tube and the use of hydraulic extruding device when sampling subsurface soils for organics or microorganisms can be used. As soon as the core is obtained, the drive shoe, if used, is removed and the sample tube is placed into the extruding device. As the core sample is forced out of the tube, the first 5 to 8 cm. (2-3 in) are cut off with a sterile scalpel and discarded.

With either method the sample material is rapidly placed within a suitable sample container. The container is tightly capped, labeled and properly stored for delivery to the laboratory.

**ANALYTICAL AND QUALITY CONTROL PROTOCOLS
FOR ANY SAMPLING AND ANALYSIS PROGRAM**

7

1.0 ADEQUATE SAMPLE IDENTIFICATION

1.1 The BKK Sample Plan includes the provision that all sample containers will have:

1. A waterproof gummed label affixed. The label will contain the following information:

- The name of the collector.
- The name and address of company sampled.
- The sample point location.
- The date and time of collection.
- The collector's sample number, which uniquely identifies the sample.

2.0 SAMPLE PRESERVATION TECHNIQUES

In a number of cases, the natural, physical, and chemical changes that a waste goes through prior to analysis may be slowed down or prevented by refrigeration at 4 to 6°C, or by the addition of preservatives. However, these treatments mostly apply to one or two components or properties. Addition of preservatives may retard biochemical changes, whereas other additives may convert some constituents into stable hydroxides, salts or compounds. Methods of preservation or stabilization are not recommended for hazardous waste samples unless only one or two components or properties are to be analyzed.

Standard method books (i.e., Manual of Methods for Chemical Analysis of Water and Wastewater, 1974, EPA-625/6-74-003, U. S. EPA, Washington, D.C.; Standard Methods for Examination of Water and Wastewater, 1975, 14th Edition, American Public Health Association, New York, N.Y.; Collection, Storage, Transportation and Pretreatment of Water and Wastewater Samples, 1971, California Department of Health Services, Berkeley, Ca.) have compilations of useful preservatives for various constituents. The following table is excerpted from these lists and shows only the preservation methods that may be used for hazardous wastes.

3.0 CHAIN OF CUSTODY PROCEDURES

3.1 The BKK Sample Plan includes the following chain of custody procedures:

1. A separate gummed chain-of-custody seal shall be affixed to the sample container in such a way that the seal would be broken when the container is opened. The seal will contain the following information:
 - The name and address of collector.
 - The signature of the person collecting the sample.
 - The collector's sample number (identical with no. on sample label)
 - The date and time of collection.
 - The name and address of company sampled.
 - The location from which the sample was collected.
2. A chain-of-custody record containing the following information:
 - The collector's sample number.
 - The signature of the collector.
 - The date and time of collection.
 - The place and address of collection.
 - The waste type.
 - The signatures of persons involved in the chain of possession inclusive of dates of possession.
3. A sample analysis request sheet containing the following information:
 - The name of the lab which will process the sample.
 - The name of the person at the lab designated to receive the sample.
 - The name of the person who does receive the sample.
 - The laboratory sample number.
 - The date of sample receipt.
 - The sample allocation.
 - The analyses to be performed.
4. At the laboratory the sample custodian shall:
 - Inspect the sample, the label, the seal, the chain-of custody.
 - Assure the sample and sample container are sound and properly preserved.
 - Assign a job number and log the sample in the log book.
 - Store the sample properly.
 - Complete the proper portions of the chain-of-custody form.
 - Notify the laboratory supervisor the sample was received.

5. Sample and Requisition Received in Laboratory

Sample identification on container is verified vs. the requisition or purchase order. Verify number of samples, type of sample, client name, adequacy (volume), preservatives (if any) and integrity (leakage). Any discrepant condition shall be noted on the requisition or Purchase Order and Sample Control Document.

6. The Sample Control Document is Written

The document must be labeled with the sequentially numbered accession number, the purchase order number (if any), receive date, due date, client name and test description. The laboratory director or supervisor will indicate the fee for test, if known, and will initial the document.

References such as maps or photographs of the sampling site field observations.
Any field measurements made (e.g., pH, flammability, explosivity).

4.0 USE OF THE EPA APPROVED ANALYTICAL METHODS

4.1 All analytical work on samples from BKK will be completed in accordance with the publication titled: Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-842, 2nd Edition, U. S. Environmental Protection Agency, 1982.

Furthermore, in order to assure the accuracy and reliability of analytical data, the following laboratory QA/QC operations will be performed during each analytical run:

1. Initial Calibration and Calibration Verification
 - A calibration blank is analyzed each time the instrument is calibrated. Calibration standards are performed to initiate any type of analysis.
2. Continuing Calibration Verification
 - To assure calibration accuracy during an analysis run, either an EPA Quality Control Solution or an NBS-traceable control-solution is analyzed for each analyte after every ten samples.
3. Preparation - Blank Analysis
 - The preparation-blank is utilized to rule out contamination by reagent preparation.
4. Interference Check Sample Analysis (ICAP)
 - The interference check sample allows the analyst to verify inter-element and background correction factors on a regular basis.
5. Contamination of Sample Container Analysis (Trip Blank)
 - Analysis of a trip blank allows a determination to be made of the potential for outside sources to contaminate the sealed sample. Analysis of the trip blank also would indicate if the sample jar was contaminated prior to collecting a sample.
6. Matrix Spike Analysis
 - The spiked sample analysis provides information about the effect of the sample matrix on the analytical methodology.
 - At least one spiked sample analysis is performed on each group of ten samples of a similar matrix.
7. Duplicate Sample Analysis
 - At least one duplicate sample analysis is performed on each group of ten samples of a similar matrix.

SAFETY PLAN FOR THE COLLECTION OF
SUBSURFACE SOIL, GROUNDWATER
AND SUBSURFACE VAPOR SAMPLES AT
BKK CORPORATION'S CLASS I LANDFILL IN
WEST COVINA, CALIFORNIA

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The placement of soil, groundwater and vapor sample collection borings in and around the BKK Corporation Class I landfill involves the potential for exposure of sampling personnel to hazardous solids, liquids and gases. This potential necessitates the development and implementation of a Safety Plan to assure that appropriate precautions are taken to provide for the health and safety of project personnel.

The Safety Plan must be based on appropriate analytical data. Table 1 presents a summary of various tests performed on ambient and subsurface gases at the landfill. The last four columns of the table present ambient air levels to which on-site workers could be exposed. The five columns following the Cal/OSHA Permissible Exposure Limit (PEL) represent undiluted subsurface vapor concentrations. The levels of compounds as measured in ambient air are one to three orders of magnitude less than the concentrations measured from the blower. The gases collected from the blower contain by far the highest concentrations of trace organics. The values reported for the other four undiluted subsurface vapor samples (flare inlet, well 10, drill rig line M and leachate sump barrier #1) are relatively consistent. The blower concentrations range from 2 to 100 times greater than the other subsurface gas concentrations. The reason for this wide range in values is not known at this time. As it is prudent to use a conservative approach, the blower unit concentrations will be considered worst case values for the undiluted subsurface vapors. The Safety Plan may be revised as additional data is generated on the types and concentrations of chemicals present in the work area.

Based on Table 1, the health and safety risks associated with chemicals present at the site can be divided into three categories:

1. Risk of fire or explosion
2. Risk of oral or dermal contact
3. Risk of vapor inhalation (particulate borne pollutants have not been identified as a concern)

There is an additional health risk not related to chemicals. Drill rigs can produce high levels of noise. To assure workers are not exposed to unsafe noise levels, on-site monitoring will be performed and noise reduction devices shall be used if necessary to control excessive noise.

1. Risk of Fire or Explosion

The first category, risk of fire or explosion has perhaps the highest probability of occurrence of the three risk categories. Methane is an odorless, colorless gas which burns with a faintly luminous flame. Methane is explosive when mixed with air (5.53 to 15 percent methane). BKK's landfill gas contains an average 40 percent methane therefore an explosive concentration could be reached a short distance downwind of the borehole. Appendix A contains procedures which will be implemented during all on-site excavation or soil borings to reduce the potential for fire or explosion to acceptable levels.

2. Risk of Oral or Dermal Exposure

This Safety Plan is based on data gathered during previous air sampling programs. The risk of oral and dermal exposure should be evaluated based

TABLE 1

Characterization of Landfill Gas at BKK's Class I Landfill*

| | Characterization of Landfill Gas at MW-1 Class 1 Landfill | | | | | | | | | | | BKK | |
|-------------------------------------------|-----------------------------------------------------------|--------------------------------------|---------|---------|---------------------|-----------------------------|----------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------------|----------|---------|
| | Cal/ OSHA PEL | Peak Concentration From Blower | Flare | | Drill Rig Line M | Leachate Sump Barrier #1 | Ambient Air Samples USC | Personnel Ambient Air @C-3 | Personnel Ambient Air Peak | Personnel Ambient Air Peak | Personnel Ambient Air Barrier #2 | | |
| | | | 8-9-83 | 8-9-84 | | | | | | | | | |
| | | | 2-10-84 | 9-19-83 | | | | | | | | 12-22-93 | 5-21-82 |
| Vinyl Chloride | 1 | 139 | | 75 | 18 | 54 | | 39 | | 0.025 | | ND | ND |
| Dichloromethane (methylene chloride) | 100 | 226 | | 13 | 13 | 93 | | 11 | | 0.880 | | 0.120 | 2.4 |
| 1,1-Dichloroethene (Dichloroethane) | 200 | 22.2 | | 6.7 | | | | | | | | | |
| 1,2-Dichloroethene (trans) | NL | 10.9 | | 4.1 | | | | | | | | | |
| 1,2-Dichloroethene (cis) | NL | 18.4 | | | | | | 3.3 | | | | | |
| 1,1-Dichloroethane | NL | 154 | | 6.7 | | | | 4.5 | | 0.580 | | ND | |
| Trichloroethene | 350 | 45.7 | | 4.1 | | | | 4 | | | | | |
| 1,1,2-trichloroethane | NL | 20.5 | | 6.5 | | | | 8.8 | | | | | |
| Tetrachloroethene | NL | 181 | | 15 | | | | 15.0 | | | | 0.1 | |
| Chlorobenzene | 75 | 160 | | | | | | 2.2 | | 0.810 | | ND | |
| Benzene | 10(S) | 134 | | 7.5 | | | | 8.1 | | 0.140 | | 0.4 | |
| Toluene | 100(S) | 434 | | 45 | | 50 | | 52 | | 9.5 | | 1.4 | |
| m,p-Xylene (as Xylene) | 100(S) | 158 | | 4.2 | | | | 20 | | | | | |
| o-Xylene (as Xylene) | 100(S) | 31.3 | | 4.2 | | | | 20 | | | | | |
| Ethyl benzene | 100 | 94.9 | | 4.1 | | | | 13 | | | | 0.4 | |
| Hexane | 500 | 1840 | | 19 | | | | 15 | | 21 | | 28 | 25 |
| 1,2-Dichloroethane (ethylene dichloride) | 10 | 976 | | 9.0 | | 800 | | 10 | | | | | |
| Iso-Octane | 300 | 221 | | | | | | | | | | | |
| Trichloroethane | NL | 285 | | | | | | | | | | | |
| 1,1,1-Trichloroethane (methyl chloroform) | 350 | 39.5 | | 1.9 | | 21 | | 1.0 | | 0.080 | | 1.8 | |
| Nonane | 200 | 64.6 | | | | | | | | | | | |
| Isopropyl Benzene | NL | 4.48 | | | | | | | | | | | |
| Propyl Benzene | NL | 5.79 | | | | | | | | | | | |
| Tetrachloroethylene (perchloroethylene) | 50 | | | | | 36 | | | | 7.3 | | ND | |
| Methane | asphyxiant | 35 | | 42 | 52 | 36 | | 41 | | | | | |

* All values in parts per million except for methane, which is in percent.

rig will be required to wear high efficiency particulate filters or half-face respirators, as well as chemically resistant boots, gloves and coveralls.

At core rig borings in areas where nearby borings indicate contaminated water and gases under pressure may be encountered, safety precautions are warranted. The water injection system used by the core rig tends to suppress gas venting and dilute any solid or liquid chemicals encountered. The driller and helper operating in such areas will be required to wear rubber boots, gloves, chemically resistant suits and hardhats with splash guards. The face shield must be lowered when the drill stems are uncoupled to add or remove additional stem. Should monitoring indicate a greater risk, the safety precautions would be increased.

At any borings where organic vapors are approaching the Cal/OSHA PEL work shall be halted until the appropriate safety precautions can be taken.

The safety precautions appropriate for each specific boring will be designed by the Safety Program Administrator and On-Scene Safety Coordinator.

At borings such as C-1 where no evidence of odors, gas pressure or discolored soils are detected and the monitoring program does not indicate any potential risks soil, drilling can proceed without special precautions. Periodic monitoring must be continued, however, to assure the situation does not change.

The monitoring program for site gases is shown in Table 2. The PID equipped with a 10.2 ev lamp gives good responses to vinyl chloride, benzene, toluene and xylene (ionization potentials 10.0, 9.25 and 8.82 respectively) but does not give a good response to dichloromethane or 1,2-dichloroethane (ionization potential 11.35 and 11.2 respectively). The FID will give a strong response to most flammable hydrocarbons. Considering the high percentage of methane present in subsurface gases it is probable that the FID will be of little use for monitoring trace organics other than methane. The critical monitoring point for the flammable gas meter shall be at the edge of the bore hole. The critical sampling point for the PID and FID shall be the workers' breathing zone. If the PID levels exceed 5 ppm or the FID levels exceed 100 ppm above background in the workers' breathing zone the work must cease until measures are taken to reduce these levels. Such measures may include the use of construction fans to disperse subsurface vapors at the source.

To determine the specific concentration of the three target compounds (vinyl chloride, benzene and 1,2-dichloroethane), color detection tubes shall be used. While excellent for day-to-day checking, the color detector tube method must be backed up by the NIOSH/OSHA approved sorbent tube sampling method described in Table 2.

Appendix B describes the specific duties of the Safety Program Administrator and the On-Scene Safety Coordinator.

APPENDIX A

Flammable Gas Control

1. Flammable Gas Control

Operating practices for construction work at a site where landfill gas and other wastes are present are more restrictive than working on native soils. Because of the potential flammability and toxicity of landfill gases, certain precautions and preventive practices are required.

a. Excavation and Trenching

On-site excavation, trenching or boring shall be conducted only in the presence of an On-Site Safety Coordinator. A qualified inspector or other trained person shall be present at the work face at all times. This person must have training and experience in both OSHA safety requirements and DOHS hazardous waste requirements. Experience in supervising a landfill excavation project would also be of value.

The On-Site Safety Coordinator shall be equipped to detect methane concentrations and potential toxic gases. The On-Site Safety Coordinator will have the authority to require each worker in the vicinity of a hazardous gas to wear appropriate protective breathing apparatus or other safety equipment as necessary. The On-Site Safety Coordinator will also have the authority to require the Contractor to operate portable fans in the vicinity of work where gases are present, in order to disperse such gases.

In matters regarding safety, the On-Site Safety Coordinator has authority to issue orders which must be followed immediately. Failure to follow an On-Site Safety Coordinator's orders is grounds for reprimand or dismissal of employees, Contractors or Subcontractors.

b. Workers On-Site

A minimum of two workers shall be on the site at all times during construction activities. Each worker in the vicinity shall be equipped with safety equipment selected by the Safety Program Administrator.

c. Smoking

Smoking shall be permitted only in an area designated by the Safety Coordinator as a "Safe Smoking Area".

d. Construction Equipment

All construction equipment exhaust systems on the site shall employee diesel engines or be equipped with spark arrestors.

e. Welding/Open Fire

Welding or open flames shall be permitted only in areas of the site approved by the Field Engineer and On-Site Safety Coordinator.

f. Clothing

Personnel shall wear safety equipment selected by the Safety Program Administrator.

APPENDIX B

Responsibilities of Safety Administrator
and On-Scene Safety Coordinator

A. Summary of Responsibilities and Tasks

The following is a summary of the responsibilities and tasks of the Safety Administrator, On-Site Safety Coordinator and other personnel involved in the sampling program.

1. Safety Program Administrator

- Responsible for managing entire safety program.
- Responsible for selecting/purchasing appropriate safety equipment.
- Responsible for evaluating program and assuring that adequate safety measures are being taken.
- Responsible for performing periodic site inspections based on Appendix D and the Safety Plan.
- Responsible for receiving information on daily operations, air sampling, etc.
- Responsible for preparing written post-project evaluation.
- Responsible for revising the safety program as necessary, and sending out revisions.
- Responsible for assuring that employees wear their respirators in a safe atmosphere for an adequate length of time before entering the hazardous area.
- Responsible for determining where sample collection and personal monitors are to be set up in conjunction with the On-Site Safety Coordinator.
- Responsible for determining when the crew is adequately trained.
- Responsible for informing employees if they have been exposed to harmful substances in excess of State or Federal standards.
- Responsible for keeping the necessary records including:
 - Records of air contaminant levels.
 - A report of every injury or illness requiring medical treatment.
- Responsible for investigating every significant accident or illness and preparing a written corrective action plan.
- Responsible for designating work area boundaries (no smoking, eating, chewing gum, etc.).
- Responsible for designating smoking areas.
- Responsible for selecting the On-Site Safety Coordinator(s) (OSSC). The Safety Program Administrator must assure the On-Site Safety Coordinator is qualified to perform the required duties. It is advisable that at least one alternate On-Site Safety Coordinator be assigned and trained.
- Responsible for reviewing the work load of the On-Site Safety Coordinator. The Safety Program Administrator may delegate portions of the On-Site Safety Coordinator's duties if it appears the work load is excessive. The Safety Program Administrator must assure that this person meets the qualifications of an On-Site Safety Coordinator.

a qualified firm. A mobile water truck can be substituted for the extinguishers.

- Responsible for assuring that a first aid kit is readily available to every work area. The On-Site Safety Coordinator is responsible for inspecting the kit(s) at least once a week to assure that adequate stocks of all supplies are available. The kit will be replenished as soon as possible.
- Responsible for assuring that a person certified in cardiopulmonary resuscitation and first aid is on-site during all work in the hazardous waste areas.
- Responsible for inspecting the site every morning.
- Responsible for coordinating all emergencies. The On-Site Safety Coordinator is to be familiar with the EPA recommended emergency procedures.*
- Responsible for inspection of SCBA's once a week.
- Responsible for assuring that visitors are adequately outfitted and trained. Visitors must be cleared by a qualified physician and provide their own fit-tested safety equipment.
- Responsible for receiving complaints, issuing new equipment.
- Responsible for assuring potable water is available on-site.
- Responsible for assuring sanitation facilities are available on-site.
- The Safety Program Administrator may designate an Assistant On-Site Safety Coordinator(s). In this case, the Safety Program Administrator must specify the duties and authority of this person.
- Responsible for assuring gasoline and other flammable liquids used on-site are stored and handled properly.

3. Subcontractors

- Responsible for the safety of all of his employees.
- Responsible for assuring the Cal/OSHA GISO and other requirements outlined are complied with.
- Responsible for keeping a record for each employee including: days worked, time in, time out, work site, and job performed.
- Responsible for assuring each employee is adequately trained for his/her duties.
- Responsible for assuring all equipment is in good repair and working order.
- Responsible for assuring that if workers may be exposed to noise levels in excess of 90 dBA, acceptable hearing protection is provided.

* Hazardous Materials Spills Monitoring: Safety Handbook and Chemical Hazard Guide, Parts A and B, U. S. EPA, January 1979, EPA 600/4-79-008.

APPENDIX C

Background Data On Chemicals*

* From Documentation of the Threshold Limit Values - Fourth Edition - 1980 American Conference of Government Industrial Hygienists, Inc. with Supplemental Documentation for 1983.

In light of the above evidence that neither acute or chronic effects occur from repeated daily exposures after many years, and that irritation may be experienced at around 20 ppm, but not at 10 ppm, the recommended TLV for vinyl acetate is 10 ppm, with a STEL of 20 ppm.

Other recommendations: USSR MAC (1976) 3 ppm; NIOSH (1978) 4 ppm ceiling.

References:

1. **Haskell Laboratory:** *Report of Toxicity of Vinyl Acetate*, E.I. du Pont de Nemours & Co., Wilmington, DE (January 1967).
2. **Mellon Institute:** Communication to TLV Committee (October 14, 1968).
3. **Deese, D.E., Joyner, R.E.:** *Am. Ind. Hyg. Assoc. J.* 30:449 (1969).
4. **Union Carbide & Carbon Corp.:** *Toxicology Range-finding Tests*, Dept. of Ind. Med. & Tox. (December 1956).
5. **Gage, J.C.:** *Brit. J. Ind. Med.* 27:1 (1970).
6. **Maltoni, C.:** Vinyl Chloride Carcinogenicity, in *Origins of Human Cancer*, Vol. 4, pp. 119-146, Cold Spring Harbor Laboratory (1977).

VINYL BENZENE

See, **STYRENE**

VINYL BROMIDE

Bromoethylene



TLV, 5 ppm ($\approx 20 \text{ mg/m}^3$), Appendix A2 — Suspected Carcinogen

Vinyl bromide has a molecular weight of 106.96 and the liquid has a specific gravity of 1.4933 at 20° C. It has a melting point of -139.54 and a boiling point of 15.80 at 760 mm Hg. Insoluble in water, it is soluble in alcohol, ether, acetone, benzene or chloroform.

This substance has not been found suitable as an anesthetic, but is useful as a fire-retardant in plastics.

The oral LD₅₀ of the 50% solution in corn oil is 500 mg/kg in male rats.⁽¹⁾ Liquid vinyl bromide is slightly to moderately irritating to the eyes, but non-irritating to intact or abraded rabbit skin. Acute inhalation studies show that 100,000 ppm is lethal to rats in 15 minutes; 50,000 ppm renders rats unconscious in 25 minutes and is lethal after 7 hours of exposure. At 25,000 ppm, rats are anesthetized, but recover rapidly even after 7 hours of exposure. Slight to moderate kidney damage was seen in rats surviving exposure to 50,000; but no histopathological changes were seen in rats exposed 7 hours to 25,000 ppm.

A sub-acute inhalation study in rats exposed to 10,000 ppm for 7 hours per day, 5 days per week, revealed significantly depressed body weights after 15 days of exposure, but no compound-related gross or microscopic pathological changes after 20 exposure days.⁽²⁾

In a chronic inhalation study, in which groups of rats, rabbits and monkeys were exposed to 250 or 500 ppm for 6 hours/day, 5 days/week for 6 months, no significant changes were detected in any of the following parameters: growth rates, food consumption (rats and rabbits only), hematology, gross pathology, organ to body weight ratios and histopathology.⁽²⁾ Measurements of blood bromide showed that the levels increased with duration of exposure to all three species and were proportional to the concentration of vinyl bromide in the test atmosphere. Estimated equilibrium values for blood bromide in monkeys exposed to 250 and 500 ppm were well below those levels at which signs of bromism were evident.

Based on interim data obtained after 12 months of a lifetime inhalation study, there appear to be serious toxic effects in Charles River Sprague-Dawley rats exposed to 1250 or 250 ppm 6 hours/day, 5 days/week.⁽³⁾ The toxic effects include increased mortality, decreased body weight, angiosarcomas of the liver and carcinomas of the zymbal glands of the ears. These responses were dose related and did not occur in groups of male and female rats similarly exposed for 1 year to 50 ppm or 10 ppm.

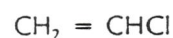
Based on these data a TLV of 5 ppm, the same as that for vinyl chloride, is recommended, as well as placement on the A2 listing as a suspected human carcinogen.

References:

1. **Torkelson, T.R.:** Unpublished data, Dow Chemical Company, Midland, MI.
2. **Leong, B.K.J., Torkelson, T.R.:** *A. Ind. Hyg. Assoc. J.* 31:1 (1970).
3. **Huntington Research Laboratory:** Unpublished Interim Report (1977).

VINYL CHLORIDE

Chloroethene



TLV, 5 ppm ($\approx 10 \text{ mg/m}^3$) — Appendix A1a — Recognized Carcinogen

A colorless, highly flammable gas with an ethereal odor, vinyl chloride has a molecular weight of 62.50. It boils at

-13.9° C and freezes at -159.7° C. Vinyl chloride is usually handled as a liquid under pressure, and containing a polymerization inhibitor (phenol). It is slightly soluble in water, but dissolved by alcohol and ether.

The chief use of vinyl chloride is as a raw material for the manufacture of polyvinyl chloride resins. It is also employed in organic syntheses.

Since vinyl chloride is a gas at room temperature and pressure, the common route of toxic exposure is by inhalation. As with many liquified gases, contact of the skin or

After leaving the working environment, a state of somnolence (45%) persists, with hypersomnia. Vinyl chloride acts on the skin and produces a sensation of formication and of heat.

2. After repeated exposure, a neurologic asthenia sets in which somnolence predominates.
3. After a variable period of time, dyspeptic disturbances are added to the neurologic manifestations; these are at first not characteristic; they are in the form of epigastric pains (16%), swelling, discomfort, feeling of heaviness in the right hypochondrium (7%) or the left (5%) with anorexia, particularly for fats. In 30.2% of the cases, congestive hepatomegaly appears, which may mimic toxic hepatitis without jaundice; some cases may become chronic. In 6% of the cases, the hepatomegaly is accompanied by splenomegaly. The proteinogram and the aldolases are the most sensitive tests and show changes similar to those of acute hepatitis: increase in α -globulins and of the β - and γ -globulins; and thymol test, Greenstedt's reaction and the zinc sulfate test are positive only in few of the cases.
4. After 3 years of exposure in 9% of the cases a syndrome typical of ulcer without radiologic changes becomes manifest.
5. In 6% of the cases the Raynaud syndrome has appeared, particularly among the young men. Plethysmography shows in half of the cases an inhibition of the vasomotor centers.
6. In addition, allergic dermatitis in 4.4% of the cases, and scleroderma in 3.6%, has been observed.
7. The clinical and laboratory findings are of great importance in occupational pathology because in numerous cases diseases appear in man that cannot be reproduced in the animal (Raynaud's syndrome and scleroderma).

The sudden and frequent appearance of these manifestations in the PVC division of several plants, and in certain divisions in normal individuals who are still relatively young, and their disappearance in the majority of the cases after the institution of protective measures and change of work, have shown us decisively that vinyl chloride and the vinyl monomers have played a part in the production of these manifestations. (End of author's summary).

In 1967, reports appeared in the literature describing a condition known as acroosteolysis in workmen engaged in polymerization of vinyl chloride to polyvinyl chloride. Harris and Adams⁽¹³⁾ reported on two cases in Europe. Wilson et al⁽¹⁴⁾ reported on 37 cases in the B. F. Goodrich Company. Juhe et al⁽¹⁵⁾ described a syndrome consisting of (arranged in decreasing order of occurrence) thrombopenia, splenomegaly, liver damage, obstruction of ventilation, circulatory obstruction, and skin and bone alteration.

As a result of this problem, the University of Michigan in 1967 was retained by the Manufacturing Chemists Association to investigate acroosteolysis in sponsoring American companies. The results of a large scale epidemiological study of workers then currently employed in vinyl chloride and polyvinyl chloride production were reported in three publications by this group Dinman et al⁽¹⁶⁾ Cook et al⁽¹⁷⁾ and Dodson et al⁽¹⁸⁾

Dinman et al⁽¹⁶⁾ summarized the study as follows:

"An epidemiological study was performed covering 5,011 employees with 21,510 man-years experience in various phases of vinyl chloride (VC) and polyvinyl chloride (PVC) manufacturing in 32 plants throughout the United States and Canada. The total number of definitive cases of acroosteolysis (AOL) was 25; 16 other individuals were under suspicion. This condition is clearly associated with the hand cleaning of polymerizers. Workers engaged in other phases of VC or PVC manufacturing do not appear to be at risk of developing AOL. The importance of Raynaud's phenomenon as a concomitant of AOL is emphasized. Several statistical approaches for rapid medical survey are suggested. Acroosteolysis appears to be a systemic rather than local disease. Presently, neither the etiological agent nor its portal of entry is known."

Cook et al⁽¹⁷⁾ describes the polyvinyl chloride production process in considerable detail. They concluded that although no etiological agent could be identified, "There appeared to be a correlation between the extent of degassing prior to entry into the reactor" and the incidence of acroosteolysis.

Mutchler and Kramer⁽¹⁹⁾ presented a paper at the 1968 Gordon Research Conference which was subsequently published (1972), which reported on *The Correlation of Clinical and Environmental Measurements for Workers Exposed to Vinyl Chloride*. The authors drew the following conclusion:

"Our findings suggest that repeated exposure to vinyl chloride at TWA levels of 300 ppm or above for a working lifetime together with a very low level of vinylidene chloride may result in slight changes in certain physiologic and clinical laboratory parameters. The possibility of some impairment in liver function tests must be considered, even though no overt clinical disease was evident in any of the individuals studied. We shall continue our study, but suggest that similar studies to help clarify the effects of this material be performed for other worker populations exposed to vinyl chloride alone."

P. L. Viola, in an attempt to produce acroosteolysis in animals, exposed rats 4 hours per day, 5 days per week to 30,000 ppm (3%) vinyl chloride vapor. In his first report on the results of 12 months exposure, he described metaplastic changes in the bones which he considered similar to the human disease acroosteolysis. He made no mention of having observed cancer in these animals until the Tenth International Cancer Congress in May 1970. In the abstracts of this meeting, and subsequently in May 1971, Viola, Bigotti and Caputo⁽²¹⁾ reported tumors of the skin, lungs and bones occurring first after 10 months of exposure. The authors summarized this work as follows:

"Rats (Ar/IRE Wistar strain) exposed for 12 months to vapors of vinyl chloride developed tumors of the skin, lungs, and bones. The cutaneous tumors, which always appeared in the area in which submaxillary and parotid glands are located, have been histologically recognized as epidermoid carcinomas, papillomas, and mucoepidermoid carcinomas. The morphological characteristics of lung tumors, which

Recent papers have included a report of 4 cases of respiratory cancer among vinyl chloride workers, but no dose-response relationship.⁽³¹⁾

On the other hand, Fox and Collier,⁽³²⁾ in a study of 7000 men exposed to vinyl chloride in PVC manufacture between 1940 and 1974, found no evidence of cancers due to vinyl chloride at sites other than the liver. There are four liver cancers, two of them angiosarcomas.

Delorme and Theriault⁽³³⁾ described 10 cases of liver angiosarcoma among workers in vinyl chloride polymerizing plant in Quebec, which were accompanied by fibrosis of the liver. Details of 64 cases were presented by Sputas and Kaminski.⁽³⁴⁾

Mutufugi, in Japan, noted that in contrast to western countries, in which 70 angiosarcomas cases (associated with vinyl chloride exposure) had been reported, no cancer, but many poisoning cases, have been reported in the USSR.⁽³⁵⁾

Based on the above data, an A1a classification as a confirmed carcinogen is given vinyl chloride and a TLV of 5 ppm as a time-weighted average is suggested. If this value is not exceeded, there should be no increase in the incidence of cancer, especially angiosarcoma of the liver.

Limits adopted in other countries, subsequent to the surfacing of vinyl chloride exposure associated cancers, as are follows, according to a 1977 summary: Australia (1973) 25 ppm; Finland (1975), Holland (1973), Poland (1976), Switzerland (1976) and USSR (1977) about 10 ppm; Italy (1975) 5 ppm; Japan (1975) and Sweden (1978) 1 ppm.

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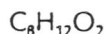
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VINYL CYANIDE

See, ACRYLONITRILE

VINYLCYCLOHEXENE DIOXIDE

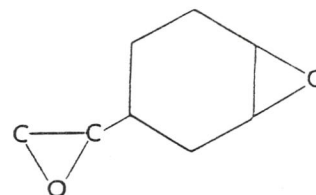
Vinylhexane dioxide



Skin

TLV, 10 ppm ($\approx 60 \text{ mg/m}^3$), Appendix A2 — Suspected Carcinogen

A colorless liquid which has a specific gravity of 1.0986 at 20° C, vinylcyclohexene dioxide's molecular weight is 140.18. Its freezing point is -108.9° C and boiling point is



228° C. The open cup flash point is 230° F and the viscosity is 7.77 centipoise at 20° C. The vapor pressure is 0.1 mm Hg at 20° C and is very soluble in water.

Vinylcyclohexene dioxide has been used by the plastic industry since the 1950's in the formation of polymers and other types of organic syntheses.^(1,2)

numerous organic chemicals. It is found in gasoline from trace amounts to as much as 30% concentration in some countries.

As an acute poison benzene produces narcotic effects comparable to those of toluene; it is a more potent narcotic than the alkanes or naphthenes of similar boiling points. But the effect of chronic exposure to this compound is by far the most serious disease caused by any of the common hydrocarbon solvents. Its action on the bone marrow may result in detectable alterations, and, in some instances, aplastic anemia. The reported LD₅₀ orally in young adult rats is 3.8 mL/kg.⁽¹⁾

It is unique among hydrocarbons as a myelotoxicant.⁽²⁾ More than 140 fatal cases of benzene poisoning had been recorded prior to 1959.⁽³⁾ Vigliani and Saita⁽⁴⁾ listed 26 deaths from chronic benzene poisoning in two provinces in Italy between 1960 and 1963. Eleven of these were diagnosed as leukemia, which may develop several years after cessation of exposure to benzene.

Most deaths from benzene have resulted from exposures of the order of 200 ppm or more. In a few instances concentrations of 1000 or even 2000 ppm have been recorded in workplaces where deaths occurred. Some of these are: Legge,⁽⁵⁾ 210 to 1050 ppm; Greenburg,⁽⁶⁾ 70 to 1800 ppm, with over half above 200; Bowditch,⁽⁷⁾ 100 to 200+ measured; one leukemia case described by Hunter⁽⁸⁾ and Mallory⁽⁹⁾ six years after exposure at over 200 ppm; Greenburg,⁽¹⁰⁾ 25 to 1000 ppm in four rooms; Helmer,⁽¹¹⁾ 140 to 200 ppm after improvements; Savilahti,⁽¹²⁾ 318, 433 and 470 ppm; Kozlova,⁽¹³⁾ 47 to 310 ppm; Vigliani,⁽⁴⁾ 190 to 660 ppm, after four years death from leukemia; Juzwiak,⁽¹⁴⁾ 31 to 156 ppm; Aksoy,⁽¹⁵⁾ 150 to 650 ppm, and 210 to 650 ppm,⁽¹⁶⁾ 26 patients with acute leukemia or preleukemia; Ikeda,⁽¹⁷⁾ 100 to 800 ppm, 7 deaths, all females, none from leukemia.

Winslow,⁽¹⁸⁾ however, reported blood changes in workers where concentrations of benzene vapor below 100 ppm were found. Heimann and Ford⁽¹⁹⁾ found one death and three cases with blood changes where air analysis for benzene showed a concentration of 105 ppm. Wilson⁽²⁰⁾ reported three fatal cases in a plant where the average concentration of benzene vapor was 100 ppm. In a fifth room, associated with benzene poisoning, Greenburg⁽¹⁰⁾ found 11 to 57 ppm. So far as can be determined the lowest measured concentration of benzene vapor associated with a fatal case of benzene intoxication (due to aplastic anemia) was the 60 ppm reported by Hardy and Elkins in 1948,⁽²¹⁾ in a plant where repeated air analyses were made, and a number of other workers showed some blood abnormalities.

Blaney⁽²²⁾ found little evidence of benzene intoxication in a group of 90 workers regularly exposed to benzene for about 13 years. Concentrations were generally low, but urinary phenol measurements indicated some exposures of the order of 25 ppm.⁽²³⁾ A followup several years later showed no evidence of persisting blood dyscrasias. No cases of leukemia are known to have occurred in this group of workers. Pagnotto *et al*⁽²⁴⁾ found workers in rubber spreading operations involving naphtha with a relatively high benzene content exposed to benzene in concentrations which were for the most part between 6 and 25 ppm. A number of blood studies showed a few abnormalities but only two were serious to warrant special consideration. In one case the possibility of leukemia was raised, but on being removed from his job and given iron therapy

the worker recovered. Because of several job changes his benzene exposure could not be reliably estimated.

The other worker was in a group studied intensively over a period of several years by Pagnotto.⁽²⁵⁾ He had a red count below four million, a hemoglobin below twelve grams and suffered from nose bleeds. His benzene exposure, as estimated from several urinary phenol determinations, was to about 40 ppm. After his exposure to benzene was terminated, his blood picture gradually returned to normal. The 38 workers in this plant were followed up for 15 years after the use of naphtha containing benzene was discontinued. None showed any signs of permanent blood abnormalities. There were three deaths, none being from leukemia. It was concluded that 25 ppm of benzene vapor is safe for most workers, but that since the margin of safety is small, a TLV of 10 ppm was recommended.⁽²⁵⁾ Elkins⁽²⁶⁾ in a summary of the findings in the rubber spreading industry, came to a similar conclusion.

These conclusions were consistent with those of Fuchs⁽²⁷⁾ in 1969, who found variations in the blood pictures of three workers but did not consider that the changes were proved to result from their benzene exposures of 19, 28 and 43 ppm, respectively. He also stated that he could find no data in the literature on proved benzene poisoning in concentrations below 16 ppm, nor could he find any Soviet report which cited reasons for decreasing the Russian MAC to 6 ppm.

Two investigators have studied the effects on rats of exposures at relatively low levels of benzene vapor extended periods. Deichmann *et al*⁽²⁸⁾ found that after 5 to 8 weeks of 5 hour/day, 5 days/week exposure at 44 and 47 ppm, rats developed a moderate degree of leukopenia, but that none resulted from 15 to 31 ppm. Nau *et al*⁽²⁹⁾ found a decrease in the white blood cell counts of rats following 756 hours of exposure at 50 ppm of benzene on a schedule of 8 hours/day, 5 days/week. Reduced amounts of DNA in the white cells, a depression in myelocytic activity, and an increase in the relative numbers of red cell precursors in the bone marrow were also observed.

There have been numerous reviews of the literature of benzene intoxication. Noteworthy are those of the National Academy of Sciences in 1976⁽³⁰⁾ and the NIOSH criteria document on benzene, published in 1974.⁽³¹⁾ As a result of this extremely thorough review, NIOSH recommended a workplace time weighted average standard of 10 ppm, with a ceiling of 25 ppm.

In 1976, however, NIOSH issued a revised recommendation for an occupational exposure standard for benzene.⁽³²⁾ The key to this recommendation is the statement in the introduction that "Because it is not at present possible to establish a safe exposure level for a carcinogen, the NIOSH recommendation is to restrict exposure to very low levels which can still be reliably measured in the workplace." A number of references are given, primarily to support the characterization of benzene as a carcinogen (leukemogen). Thus most relate to leukemia cases associated with heavy benzene exposures, either measured or inferred from association with numerous cases of aplastic anemia or other blood dyscrasias. Others are epidemiologic studies on cancer in which no evidence of the degree, or even fact, of benzene exposure is cited. Thus in at least two of these papers,^(33,34) the word "benzene" does not appear. In these and other papers the incidence of various types of cancer,

exposure standard, insofar as the TLV can be defined as such a standard. There is little evidence that exposure to benzene at concentrations below 25 ppm causes blood dyscrasias of any kind. Setting the TLV at 10 ppm, as a time-weighted average, provides an added margin of safety.

If the standard is to be set at the lowest practicable detectable limit, it is the opinion of some members of the Committee that a value lower than 1 ppm should be selected. In the absence of interfering substances benzene vapor can be measured with reasonable accuracy in concentrations at least as low as 0.1 ppm; in the presence of certain interferences, it may be difficult to achieve the prescribed accuracy and reliability even at concentrations somewhat above 1 ppm.

Because the effects the TLV is designed to prevent are chronic in nature, a ceiling designation is not appropriate and a STEL of 25 ppm is recommended.

Other recommendations: ANSI (1969) 10 ppm; Czechoslovakia (1969) 16 ppm; USSR (1972) 1.6 ppm; DDR (1973) 16 ppm; Sweden (1975) 10 ppm; BRD (1974) 0 ppm (treats as carcinogen).

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50 to 10 ppm has been adopted and a STEL of 15 ppm is recommended.

Other recommendations from a 1977 listing: West Germany, Sweden, Switzerland, 20 ppm; Czechoslovakia, East Germany, Romania, Yugoslavia, 12 ppm; Poland, U.S.S.R., 2.5 ppm; others, including Japan and the Council of Europe retained the 50 ppm value. In 1978 Sweden reduced its TWA to 5 ppm, and in 1979 West Germany added the designation of potential carcinogen, but retained the 20 ppm MAK.

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ETHYLENE GLYCOL



Vapor and Mist

CEILING LIMIT, 50 ppm ($\approx 125 \text{ mg/m}^3$)

Ethylene glycol is a clear, colorless, syrupy, hygroscopic liquid with a sweet taste, but without odor. It has a molecular weight of 62.07 and, at 20° C, a specific gravity of 1.1135 and a vapor pressure of 0.06 mm Hg. At this temperature, its saturation in air is 0.0079% (79 ppm); at 25° C, however, its saturation is 0.0131% or 131 ppm and thus, can exceed the TLV. It melts at -13° C, boils at 197.6° C, has a high flash point of 240.8° F, an autoignition temperature of 775° C and is combustible. Ethylene glycol is miscible with water, alcohol and ether.

It is used as an antifreeze in heating and cooling systems, an industrial humectant and as a solvent in the paint and plastics industries.

The low vapor pressure of ethylene glycol virtually precludes excessive exposure to the vapors at room temperature. Exposure to vapor and mists of ethylene glycol is possible, however, at elevated temperatures, and adverse effects have been reported from exposure to mists.

The available toxicologic data were summarized in 1962 by Patty,⁽¹⁾ who concluded that 100 ppm (250 mg/m³) was an acceptable level for repeated, daily exposures to the vapor. If repeated, prolonged, exposures are limited to 100 ppm the likelihood of systemic or eye injury is quite remote. Troisi⁽²⁾ describes nystagmus in excessively exposed workers, but did not report irritation.

In 1970, Coon et al⁽³⁾ reviewed some of the available data and described exposure of rats, guinea pigs, rabbits, dogs and monkeys at 10 and 57 mg/m³ eight hours/day, five days/week for 30 days. No adverse effects resulted from these exposures. However, this group also exposed

animals 24 hours per day for 90 days at a concentration of 12 mg/m³ and reported moderate to severe eye irritation in rabbits and rats. Wiley et al⁽⁴⁾ exposed animals at 350-400 mg/m³ (estimated) essentially saturated vapor concentrations 8 hours/day for 16 weeks without producing an effect. They⁽⁴⁾ apparently exposed animals to an atmosphere generated by bubbling air through a liquid sample. Coon et al⁽³⁾ metered liquid ethylene glycol, and then aspirated metered liquid into the airstream without heat. The reasons for the marked differences in findings between these two groups of investigators is not known.

In a study with human volunteers⁽⁵⁾ exposed 22-20 hr/day at a mean concentration of 12 ppm or about 30 mg/m³ of ethylene glycol for about four weeks, there were some complaints of irritation of the throat, mild headache and low backache, but on the whole, the exposure was very well tolerated. The complaints became marked when the concentration of ethylene glycol within the exposure chamber was raised above 140 mg/m³ for part of a day.

The most common complaint was irritation of the upper respiratory tract. The symptoms seemed to correlate well with the concentration of ethylene glycol in the ambient air. Concentrations of about 80 ppm or more were intolerable, with a burning sensation along the trachea and a burning cough. The irritative phenomena became common when the concentration was raised to about 60 ppm.

The above study⁽⁵⁾ used aerosolized ethylene glycol. At the higher levels considerable amounts of mist are believed to have been present. The quantity of particulate inhaled when concentrations were well below that needed to saturate the air (131 ppm at 25° C, considerably higher at body temperature), is not known. The analytical method did not distinguish between mist and vapor.

It seems impractical to establish separate TLVs for vapor and mist for a liquid with the volatility and toxicity of ethylene glycol. A change to a ceiling of 50 ppm, for mist and vapor combined, is recommended to minimize irritation of the respiratory passages.

lene chloride continued after exposure ceased. This solvent-induced COHb is apparently added to the body burden of carbon monoxide derived from other sources.

This study corroborated previous single exposure studies in that no deleterious effects upon the health or performance of healthy adults could be detected when they were repeatedly exposed to 250 ppm or less for 7.5 hours per day, five days per week for 2 weeks, or in the case of the male subjects, to 500 ppm on two consecutive days.⁽¹⁴⁾ Among the parameters studied were complete blood count, clinical chemistry (SMA 12), EKG, serum triglycerides, blood pressure, subjective signs and symptoms, urinalysis (Combistix) urinary urobilinogen, neurological tests, EEG, visual evoked response, pulmonary function and cognitive, alertness, time estimation, coordination, arithmetic and inspection tests.

The increase in COHb was related to the magnitude of the vapor exposure. Both duration of exposure and vapor concentration were factors. Seven and one-half hour exposures to concentrations as low as 100 ppm for 5 days resulted in COHb elevations about 5 percent in nonsmokers. The odor was not objectionable at 250 ppm and many subjects could not detect it at 50 or 100 ppm.

Since the toxic effects of methylene chloride are due in part to its conversion to carbon monoxide, they would presumably be augmented by the presence of carbon monoxide in the air. Poder *et al*⁽¹⁵⁾ found the effects of CO and the COHb from methylene chloride to be additive in 3-hour exposure tests with rats. Therefore, whenever there is a combined exposure to the vapors of methylene chloride and carbon monoxide, the appropriate equation for mixtures should be used, in determining whether or not the exposure is acceptable.

A time-weighted average TLV of 100 ppm is recommended for methylene chloride in the absence of occupational exposure to carbon monoxide. This recommendation is based upon experimental data obtained from non-smoking males at rest, and should keep COHb levels well below 5 percent. A STEL of 500 ppm is recommended since data indicate that neither undesirable CNS responses nor COHb values are likely to occur with such exposures to methylene chloride.^(14,17-20) Concurrent exposure to other source of carbon monoxide or physical activity will require assessment of the overall exposure and adjustment for the combined effect.

Other recommendations: NIOSH (1976) 75 ppm; West Germany (1979) and Elkins (1959) 200 ppm; ANSI (1969) 500 ppm; USSR (1970) 15 ppm; East Germany (1973), Romania (1975), Yugoslavia (1971) and Czechoslovakia (1976) 140 ppm; Sweden (1974) 100 ppm; others 200 or 250 ppm.

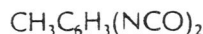
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TOLUENE-2,4-DIISOCYANATE

TDI



TLV, 0.005 ppm ($\approx 0.04 \text{ mg/m}^3$)

STEL, 0.02 ppm ($\approx 0.15 \text{ mg/m}^3$)

TDI is a liquid at room temperature with a sharp pungent odor. The molecular weight is 174.16. The two commonly used isomers are 2,4-toluene diisocyanate and 2,6-toluene diisocyanate, commercially available in the following three ratios: 1) 100% 2,4; 2) 80% 2,4:20% 2,6; 3) 65% 2,4:35% 2,6. The 80% 2,4:20% 2,6 mixture represents over 95% of the industrial usage and has the following properties: at 25° C, specific gravity 1.22 and vapor pressure 0.5 mm; boiling point 250° C; freezing point 20-22° C; closed cup flash point 270° F. TDI is miscible with alcohol, ether, acetone carbon tetrachloride, benzene and kerosene.

TDI is one of the isocyanates most employed in the manufacture of polyurethane foams, elastomers and coatings. The foams are widely used in furniture, packaging, insulation and boat building, and have many other applications. Polyurethane coatings have many desirable properties, on leather, wire, tank linings and masonry. Elastomers are abrasion and solvent resistant and are used in adhesives, films and linings, and in abrasive wheels and other mechanical items.

Studies in animals by Zapp⁽¹⁾ showed that this isocyanate has a low oral toxicity (approximate lethal dose 5.8 g/kg) but a high toxicity by inhalation. One to two ppm for 30 six-hour exposures resulted in tracheobronchitis. The LC₅₀ for three rodent species for a four-hour exposure approximated 12 ppm, according to Duncan *et al.*⁽²⁾ The animals died of pulmonary edema and hemorrhage. Effects on the liver, kidneys and gastrointestinal tract were also noted, and dermal effects occurred. Repeated daily six-hour exposures at 0.1 ppm were reported to cause chronic inflammation of the tracheo-bronchial mucosa with fibrosa obliterans as the terminal lesions.⁽³⁾ A fever reaction in animals following intravenous injection of 0.02 mg/kg was reported by Scheel *et al.*⁽⁴⁾

TDI is an irritant causing inflammation and occasional sensitization of the skin, lacrimation, smarting, burning and prickling sensation to the eye; abdominal distress, nausea and vomiting, but the major effect is on the respiratory tract.^(1,5)

One type of respiratory response is irritation, indicated by a burning nose and throat, and a choking sensation.

With high concentrations this may lead to chemical bronchitis with severe bronchospasm.⁽⁶⁾ With sufficient exposure any person will experience these effects even on first exposure.⁽⁷⁾ Chemical pneumonitis, pulmonary edema, headache, insomnia have also been reported.

A second respiratory response to TDI is that of sensitization. Some individuals become sensitized on first exposure while others may develop symptoms after exposure over days, months or years. Other workers have had only minimal or no respiratory symptoms for several months of low level exposure, then suddenly develop acute asthmatic reaction to the same level.

The nature of the sensitization process is unknown and many authors have referred to it as allergy, and to the respiratory response in sensitized people as true asthma, comparable to asthma excited by pollens and other exo-allergens. Some TDI sensitized people however, have no history of prior allergic disease.

In a 1963 review Brugsch and Elkins⁽⁸⁾ noted reports of 318 cases of TDI intoxication prior to 1961, including two deaths. In most instances data on exposure levels were lacking. Walworth and Virchow,⁽⁹⁾ however, reported 83 cases in a plant where the average TDI concentrations ranged from 0.01 to 0.16 ppm. The maximum incidence of cases occurred when the average concentration of vapor was around 0.1 ppm; very little trouble was noted at 0.01 ppm. Hama⁽¹⁰⁾ found TDI vapor levels of 0.03 to 0.07 ppm associated with a high incidence of illness, but no cases were observed from concentrations below 0.03 ppm. Munn⁽¹¹⁾ considered the 0.1 ppm limit too high.

Elkins *et al.*⁽¹²⁾ reported 42 accepted or established cases of TDI intoxication, and 73 questionable or disputed cases, among workers in 14 plants in Massachusetts between 1957 and 1962. In 14 of the accepted cases the average TDI vapor concentration found in the workroom was about 0.03 ppm, with very few samples showing more than 0.05 ppm; in 11 cases the average concentration was 0.015 ppm; in 9 cases levels below 0.01 ppm were found; in the remainder measurements representative of worker exposure could not be made. The authors recommended a TLV of 0.01 ppm.

According to Thompson and Scheel,⁽¹³⁾ studies with rats support the probability that lung reactivity to TDI is due to chemical damage and not antibody reactions. Markham and Fishburn⁽¹⁴⁾ reported that workers were affected by concentrations generally below 0.02 ppm. Bruckner *et al.* described a study of clinical and immunological factors which tended to support the former TLV of 0.02 ppm.⁽¹⁵⁾

A third type of respiratory response to TDI is that of acute and chronic decrease of ventilatory capacity mea-

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m-XYLENE α , α' -DIAMINE

MXDA



Skin

CEILING LIMIT, 0.1 mg/m³

MXDA is a colorless liquid with a molecular weight of 136.19. It boils at 247° C and solidifies at 141.1° C. With a measured vapor pressure of 15 mm at 145° C, the calculated vapor pressure at 25° C is about 0.03 mm Hg. It has an open cup flash point of 273° F and is miscible with water and alcohol, but only partially soluble in paraffin hydrocarbon solvents.

Polyamide fibers and resins made from MXDA have a number of useful properties. It is also used as a curing agent for epoxy resins, and as a source of m-xylylene diisocyanate.

Two studies have indicated it to have a rather low oral acute toxicity to the rat (1500 and 930 mg/kg, respectively,⁽¹⁾ but, to be strongly irritating to the skin. A dermal LD₅₀ of 2000 mg/kg was found for rabbits.⁽²⁾ The undiluted compound was corrosive to the skin of guinea pigs, and a 50% emulsion in an acetone-dioxane mixture was severely irritating, but little effect was produced by a concentration of 10%.⁽¹⁾ A 10% aqueous solution, however, caused severe erythema and irritation, yet repeated application of a 5% concentration was needed to produce swelling and redness.⁽²⁾

In one study evidence of mild sensitization was found following repeated application to guinea pig skin,⁽¹⁾ but this finding was not duplicated in the second investigation.⁽²⁾

Exposure of rats for one hour to an aerosol of MXDA, at measured concentrations ranging from 1.74 to 6.04 mg/liter, resulted in eye irritation, lacrimation and labored breathing.⁽²⁾ No deaths occurred during exposure, but several animals died within 48 hours, and a few more later, up to 14 days, the end of the observation period. Of the animals which survived, female rats showed reduced weight gain, while that of males was near normal.

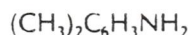
At necropsy macroscopic abnormalities were found chiefly in the lungs, however changes in liver and kidneys were also noted. The LC₅₀ for a one hour exposure and 14 day observation period was 3.75 mg/L, or about 700 ppm.

In comparison with the better known phenylene diamine (q.v.), the dermal effects of MXDA seem similar, but the oral toxicity appears less. By analogy, a ceiling limit of 0.1 mg/m³ is recommended for MXDA, until more information is available. At this concentration, the compound should be largely in the vapor state.

References:

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XYLIDINE



Skin

TLV, 2 ppm (\approx 10 mg/m³)

STEL, 10 ppm (\approx 50 mg/m³)

Xylidine is a pale yellow to brown liquid with a molecular weight of 121.18. Commercial xylidine, a mixture of isomers, has a specific gravity of 0.97 to 0.99 and a boiling range from 213 to 226° C. It has a flash point of 202° F and a reported vapor pressure of \leq 1 mm Hg at 20° C. Sparingly soluble in water, xylidine is miscible with alcohol and ether.

It is a raw material in the manufacture of dyes, pharmaceuticals and other organic compounds.

Von Oettingen and co-workers⁽¹⁾ found that by oral administration to dogs xylidine was less toxic than aniline, and resulted in very much less methemoglobin formation. Similar results were obtained by cutaneous application. With cats, however, xylidine and aniline were approximately equally toxic when applied to the skin, although the former acted much more slowly.

Upon inhalation, the LC₅₀ for seven hours for mice was 149 ppm for xylidine and 188 ppm for aniline.

Repeated exposure to xylidine at 45 ppm seven hours a day for 20 to 40 weeks resulted in mortality among dogs, cats and mice, but little or none among rats, rabbits, monkeys and chicks. Liver damage was noted in rats, cats, dogs and mice.

Treon and associates⁽²⁾ compared the toxicities of xylidine and monomethyl aniline. The minimum lethal oral dose for rabbits was 620 mg/kg; by intravenous injection 240 mg/kg was lethal for rabbits, and 120 mg/kg for cats. In

APPENDIX D

Program Evaluation

XXII. PROGRAM SELF-EVALUATION

On the following pages you will find sixty-two questions with which you may evaluate your program. The numbers found in the parenthesis after each question key it to the section(s) of the manual that can help you rectify a "No" answer.

Subpart I - Personal Protective Equipment

| 1910.134 - Respiratory Protection | Yes | No | Manual Reference (section #) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------|------------------------------|
| 1. Are engineering controls being used when feasible to control atmospheric contamination? | <input type="checkbox"/> | <input type="checkbox"/> | I |
| 2. Does the employer provide respiratory equipment when necessary? | <input type="checkbox"/> | <input type="checkbox"/> | I, III, VI |
| 3. Does the employee use the respiratory protection in accordance with instructions and training he received? | <input type="checkbox"/> | <input type="checkbox"/> | XVII, XX |
| 4. Are there written operating procedures governing the selection and use of the respirators? | <input type="checkbox"/> | <input type="checkbox"/> | II |
| 5. Are the respirators selected for the particular hazard? | <input type="checkbox"/> | <input type="checkbox"/> | VI |
| 6. Does the employee receive training in the use of the respirator and its limitations? | <input type="checkbox"/> | <input type="checkbox"/> | VI-XIII, XVII, XX |
| 7. Are respirators assigned on an individual basis, when practical? | <input type="checkbox"/> | <input type="checkbox"/> | II |
| 8. Are respirators cleaned and disinfected on a regular basis? (When used by more than one person - after each use; individually assigned - after each day's use). | <input type="checkbox"/> | <input type="checkbox"/> | XXI |
| 9. Are respirators stored in a convenient, clean and sanitary location? | <input type="checkbox"/> | <input type="checkbox"/> | XXI |
| 10. Are respirators checked during cleaning and deteriorated parts replaced? | <input type="checkbox"/> | <input type="checkbox"/> | XXI |
| 11. Are respirators used for emergencies checked on a monthly basis and after each use? | <input type="checkbox"/> | <input type="checkbox"/> | II, XIV |
| 12. Is there appropriate surveillance of the work area? | <input type="checkbox"/> | <input type="checkbox"/> | III |
| 13. Is the level of exposure to an employee maintained? | <input type="checkbox"/> | <input type="checkbox"/> | II |
| 14. Is there a continual evaluation of the effectiveness of the respiratory program? | <input type="checkbox"/> | <input type="checkbox"/> | V |
| 15. Before employees are assigned a task that requires the employee to wear a respirator, is he checked to see if he can perform the work and use the equipment? | <input type="checkbox"/> | <input type="checkbox"/> | IV |
| 16. Is the medical status of an employee who wears a respirator checked periodically? | <input type="checkbox"/> | <input type="checkbox"/> | IV |
| 17. Are the respirators approved by the U.S. Department of Health, Education, and Welfare (National Institute for Occupational Safety and Health) or the U.S. Department of the Interior (Bureau of Mines)? | <input type="checkbox"/> | <input type="checkbox"/> | VI |

* Respiratory Protection, A Manual & Guidelines, First Edition
American Industrial Hygiene Association 1980

| | Yes | No | Manual Reference (section #) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------|------------------------------------|
| 37. Is communications (visual, voice or signal line) maintained between all individuals present in toxic or oxygen-deficient atmospheres? | <u> </u> | <u> </u> | <u>X, XIV, XX</u> |
| 38. Are there emergency plans and proper rescue equipment present? | <u> </u> | <u> </u> | <u>X, XIV, XX</u> |
| 39. Are safety harnesses and safety lines or other equivalent provisions for the rescue of persons using air line respirators in atmospheres immediately hazardous to life or health used? | <u> </u> | <u> </u> | <u>X, XX</u> |
| 40. When persons are using air line respirators in atmospheres immediately hazardous to life or health, is there at least one standby man with suitable self-containing breathing apparatus available at the nearest fresh air base for emergencies? | <u> </u> | <u> </u> | <u>X</u> |
| 41. Is there frequent random inspection to assure that the respirators are properly selected, used, cleaned, and maintained? | <u> </u> | <u> </u> | <u>XXI</u> |
| 42. Does the training of employees who use respirators include: proper fitting; testing its face-piece-to-face seal; wearing in normal air for a familiarity period and wearing it in a test atmosphere? | <u> </u> | <u> </u> | <u>XVII, XVIII, XIX</u> |
| 43. Are employees instructed not to wear beards, sideburns, skull caps, or temple pieces on glasses that project under the respirator. (Reason: Cannot get a good seal between respirator and face) | <u> </u> | <u> </u> | <u>XVI</u> |
| 44. Does the employee check the respirator after putting it on for proper fit? | <u> </u> | <u> </u> | <u>XVIII, XIX</u> |
| 45. Are provisions made for people who wear corrective glasses and also must use a respirator? | <u> </u> | <u> </u> | <u>XVI</u> |
| 46. Are employees instructed not to wear contact lenses with a respirator? | <u> </u> | <u> </u> | <u>XVI</u> |
| 47. Are self-contained breathing apparatuses inspected monthly? | <u> </u> | <u> </u> | <u>XI</u> |
| 48. Is a record maintained of inspection dates and findings of respirators maintained for emergency use? | <u> </u> | <u> </u> | <u>II, XIV</u> |
| 49. Is replacement or repair of respirators done only by experienced people with designated parts? | <u> </u> | <u> </u> | <u>XXI</u> |
| 50. Are reducing or admission valves or regulators adjusted or repaired by the manufacturer or a trained technician? | <u> </u> | <u> </u> | <u>X, XI, XX</u> |
| 51. Is the location of respirators used for emergencies clearly marked? | <u> </u> | <u> </u> | <u>XIV</u> |
| 52. Are employees instructed of the correct way to store respirators? | <u> </u> | <u> </u> | <u>XXI</u> |
| 53. Are checks made to see that employees are not storing respirators in tool boxes or lockers without being in proper containers? | <u> </u> | <u> </u> | <u>XXI</u> |

APPENDIX D

Forms

EMPLOYEE RESPIRATOR ASSIGNMENT RECORD (FORM RP-3)

1. Plant Name _____ 2. Plant No. _____ 3. Date _____
 4. Employee Name _____ 5. Clock No. _____
 6. Job Title _____ 7. Work Location _____

RESPIRATOR ISSUE

8. Type of Respirator(s) to be issued _____

 9. To be used under the conditions specified here _____

 10. Estimated frequency of cartridge/ filter replacement or respirator replacement (disposable) — Air purifying respirators only
 Hourly ☐ Twice/shift ☐ Daily ☐ Weekly ☐ Monthly ☐ Other/specify ☐

MEDICAL SURVEILLANCE

11. At this examination on _____, no contraindications to the use of the equipment described in Item 8 have been identified.

Physician's Signature _____

Re-Examination

Date _____ Contraindications: yes _____ no _____

Comments _____

Physicians's Signature _____

Date _____ Contraindications: yes _____ no _____

Comments _____

Physicians's Signature _____

**STATEMENT OF PROVISIONS
FOR GAINING ACCESS**

9



STATEMENT OF PROVISIONS FOR GAINING ACCESS

There is presently no indication that access to adjacent properties will be required for obtaining liquid samples. This is because: adequate sampling can be taken on site of any possible surface runoff; there is no evidence of offsite leachate migration; and, there are no water wells in the area that are suspected as being susceptible to contamination from the site. Adjacent property owners are served by water supplied by water imported by the Metropolitan Water District of Southern California.

Access to adjacent property for air quality sampling is available through cooperative agreement. The South Coast Air Quality Management District has for several years established sampling stations at various locations, and there is no indication that additional access cannot be obtained if needed.

If additional sampling at or under adjacent properties becomes necessary the procedures to be followed will consist of (1) personal contact of the property owner by a BKK Corporation representative to explain the need for sampling; 2) preparation of a written sampling plan to be submitted for approval to the appropriate regulatory agencies and the property owner; (3) BKK Corporation sampling in accordance with the approved plan, including the provision of split samples for regulatory agency analysis.

CERTIFICATION OF CONSISTENCY

10



CERTIFICATE OF CONSISTENCY

In order to ensure that the plans set forth in this document are consistent with and include such requirements for investigative activities as may be required by the State of California Department of Health Services, and other agencies with interest, BKK Corporation is circulating copies of this document to the following organizations:

California Regional Water Quality Control Board

California Department of Health Services

United States Environmental Protection Agency, Region IX

South Coast Air Quality Management District

LeRoy Crandall and Associates

Mandeville and Associates

BCL Associates, Inc.

BKK Director of Landfill Engineering

CONTRIBUTING CONSULTANTS

11



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| Donald L. McCann | California Registered Geologist California Certified Engineering Geologist |
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| | |
|-----------------------|---------------------------|
| Richard T. Mandeville | |
| Hugh A. Walker | |
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| | |
|---------------------------|---------------------------|
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